Big Telescope Sweepstakes!

Relativity on Trial: the Case of DI Herculis

ASTRONOMY®

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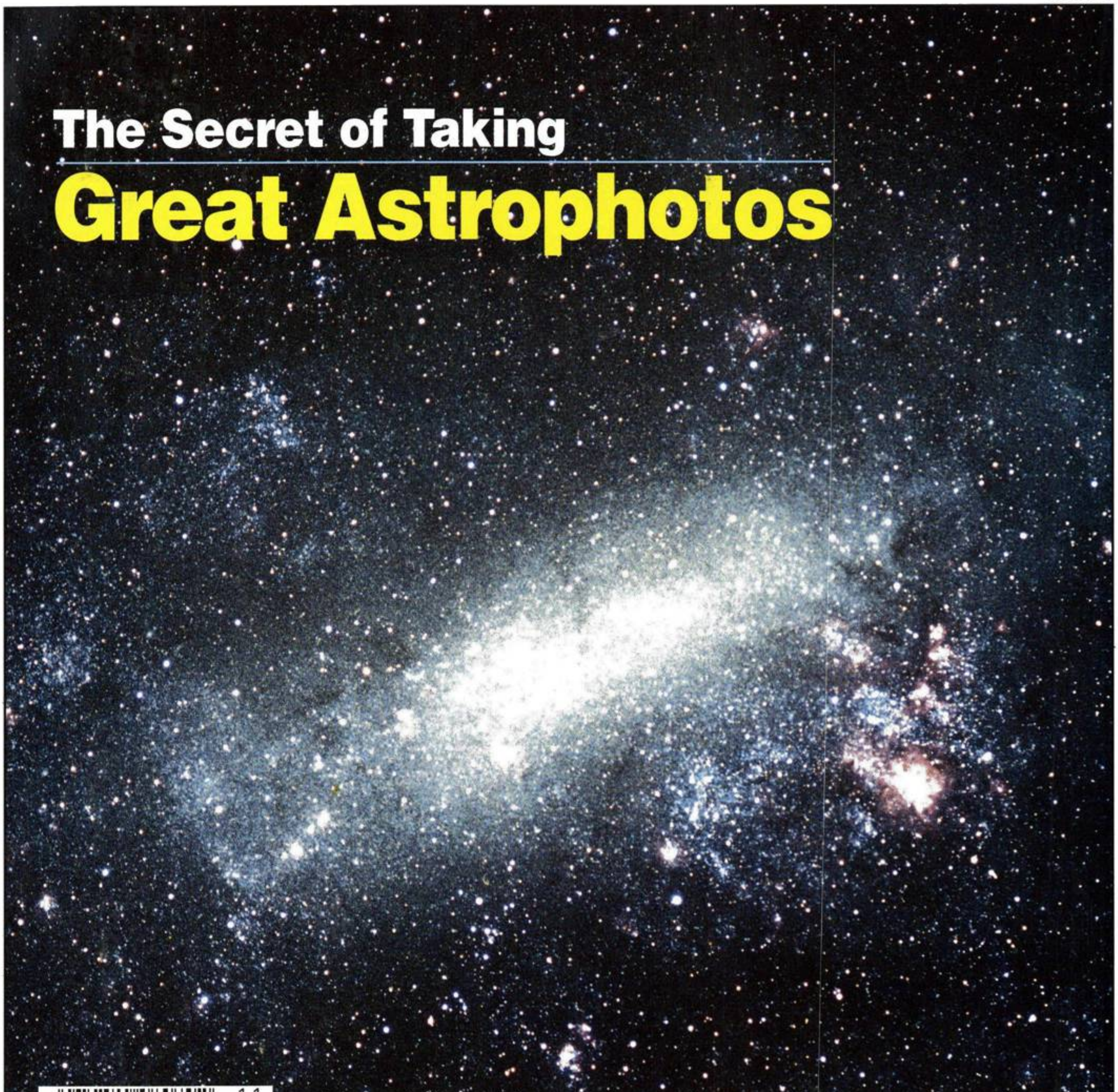
Why Can't We See the Big Bang?



The Secret of Taking Great Astrophotos

Take Your Telescope to the Deep-Sky Zoo

Where Is Amateur Astronomy Going?

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12"
MEADE LX200 EMC
10"
MEADE LX200 EMC
7"
MEADE LX200 EMC
8"
MEADE LX200 EMC
Meade
MEADE LX200

ME

LX200

The largest-selling serious telescopes in the world.

In virtually every country in the world where serious telescopes are sold, more Meade LX200's are sold than all competing models ***combined***. Consider these *standard-equipment* specifications:

- **Superb Optics:** LX200 imaging capabilities are a legend in the industry; we regularly receive reports stating that optical performance approaches that of a fine *ED* apochromatic lens.
- **Automatic GO TO Capability:** Meade LX200's are *the only commercial telescopes ever manufactured* that automatically GO TO any input R.A. and Dec., or to any of over 64,350 objects in the onboard database, *to a precision of one arc-minute or better.*
- **Meade LX200 High-Precision Pointing™** is so precise it permits the positioning of *every* selected object on *every* commercially-available CCD chip *every* time, automatically — *a feat that no other telescope priced under $40,000 can accomplish.*
- **Permanently-Programmable Smart Drive™** routinely achieves 5 arc. sec. periodic error, an observatory standard.
- **9-Speed Dual-Axis Electronics:** Electronics that cover every possible contingency of telescope positioning—from 2x photo-guide, to 32x image centering, to 8°/sec. slewing across the sky, as well as 6 other dual-axis drive speeds in between.
- **Field Operation:** No other telescopes of such incredible capabilities transport so readily for field operation. The optional #1812 Electronic DC Adapter (a compact 4 oz. unit) allows for field powering directly from an auto cigarette lighter plug.

SPECIFICATIONS: 7", 8", 10", and 12" LX200's—Each complete telescope includes 8" or 10" (f/6.3 or f/10) or 12" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and multi-function control panel; manual and electric slow-motion controls on both axes; keypad hand controller with digital readout display, permanently programmable Smart Drive, 9-speed drive controls on both axes (7-speed on 12"), High-Precision Pointing, and GO TO controller; 64,359-object onboard celestial software library; 25 ft. power cord and adapter for telescope operation from 115v.AC; 8 x 50mm viewfinder; 1.25" diagonal prism (7", 8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (7", 8", 10") or giant field tripod (12"); complete operating instructions.

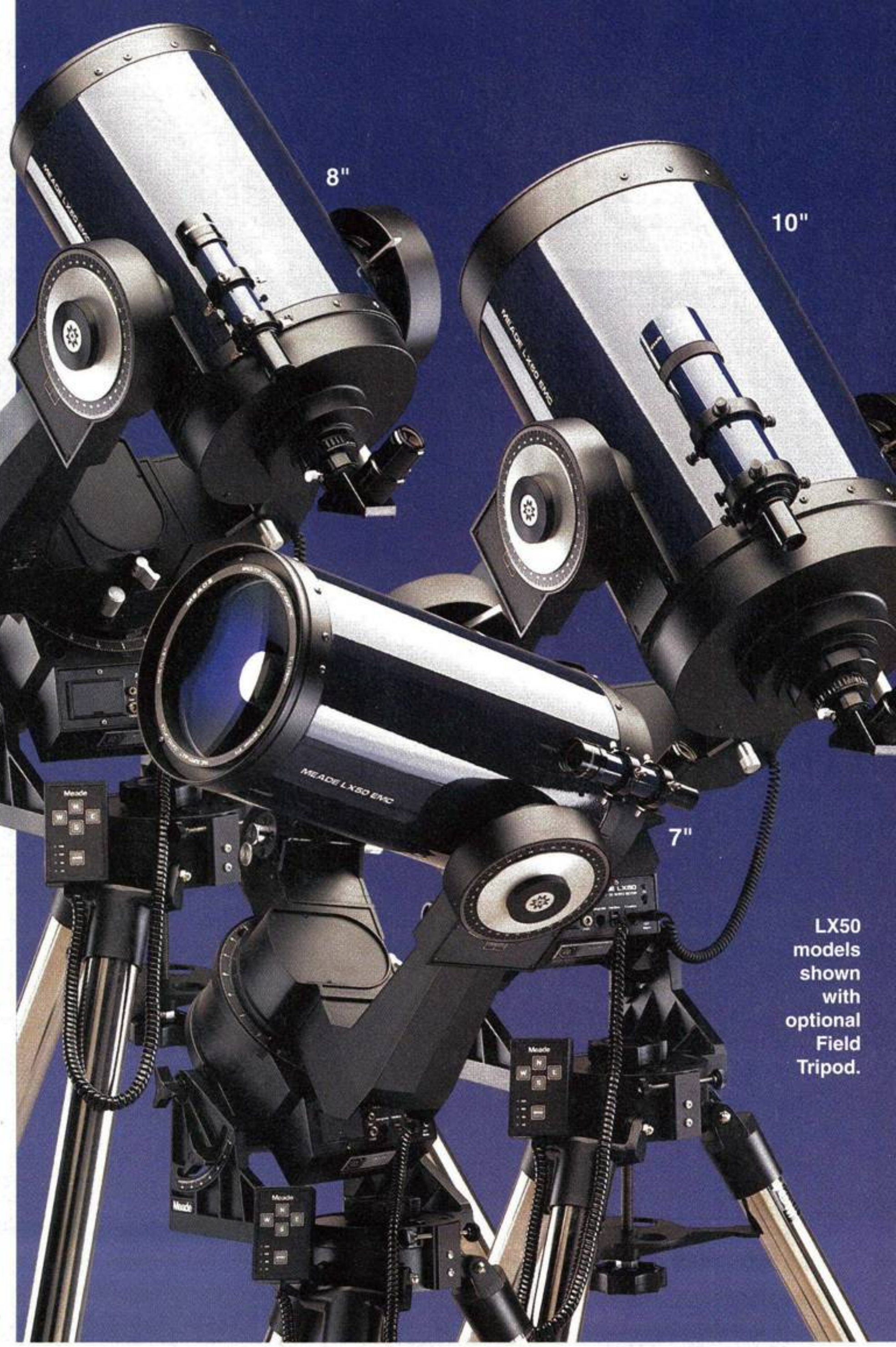
8" LX200 Schmidt-Cassegrain	**$2495.**
10" LX200 Schmidt-Cassegrain	**2895.**
12" LX200 Schmidt-Cassegrain	**3995.**
7" LX200 Maksutov-Cassegrain	**2995.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 12"—$215; 7"—$125.

ADE

LX50

Advanced technology at the most affordable prices *ever*.



LX50 models shown with optional Field Tripod.

- **Battery-Powered, Completely Cordless Operation!** Meade LX50 models operate for more than 50 hours from four AA-size batteries inserted through the telescope's control panel. Or use the standard-equipment 25 ft. cord to power the telescope directly from any auto cigarette lighter plug.

- **Standard-Equipment Declination Motor and Hand Controller:** Plug the hand controller into the LX50 control panel and you're ready for full dual-axis drive capability at any of 4 photo-guide or microslew speeds: 2x, 8x, 16x, or 32x, plus quartz-controlled sidereal-rate tracking in R.A. Switch speeds instantly using the speed-control button on the hand controller. Dual-axis drive rate is indicated by a red LED.

- **Multi-Function Control Panel:** Includes control panel connectors for CCD autoguider/imagers; electric focuser; and for the standard-equipment Declination motor. A North-South switch permits telescope operation anywhere in the world.

- **Super Multi-Coated Optics:** The exact same EMC super multi-coated optical tube assemblies included with Meade LX200 models.

- **Massive LX200-type Fork Mounts:** Meade LX50 mounts are manufactured of the same virgin aluminum castings as Meade LX200 Schmidt-Cassegrains. Massive, rigid mountings that include the Meade LX worm-gear drive system with low periodic error for advanced photographic or CCD imaging applications. *No competing mid-priced equatorial mountings even come close.*

SPECIFICATIONS: 7", 8", and 10" LX50's—Each complete telescope includes 8" or 10" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty LX200-type fork mount; 5.75" LX worm gear system in R.A.; multi-function control panel; DC servo Declination motor; manual and electric slow-motion controls on both axes; setting circles on both axes; keypad hand controller; 4-speed drive controls on both axes; battery compartment accepting four (user-supplied) AA-size batteries; 25 ft. power cord for telescope operation from 12v. auto cigarette lighter plug; 6 x 30mm (7" and 8" models) or 8 x 50mm (10") viewfinder; 1.25" diagonal prism; MA25mm multi-coated eyepiece (1.25"); standard equatorial wedge with elevation scale, bubble level, and azimuth control; complete operating instructions.

8" LX50 Schmidt-Cassegrain	**$1195.**
10" LX50 Schmidt-Cassegrain	**1495.**
7" LX50 Maksutov-Cassegrain	**1595.**
Variable-Height Field Tripod	**295.**
7" Maksutov-Cassegrain Tube Ass'y, only	**1195.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 7"—$125; 7" Tube Assembly—$65.

For complete details on Meade LX200 and LX50 telescope models, send $3.00 to Meade Instruments for the 76-page **1995 Meade General Catalog.** ■ Prices shown are suggested U.S.A. mail-order retail prices, exclusive of any sales taxes or credit card charges.

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Orders: 800-422-7876; Information: 405-364-0858

CALIFORNIA TELESCOPE COMPANY, Burbank, CA
Orders & Information: 818-505-8424

CITY CAMERA, Dearborn, MI
Orders: 800-359-5085; Information: 313-846-3922

FOCUS CAMERA, Brooklyn, NY
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EFSTONSCIENCE, Toronto, Ontario
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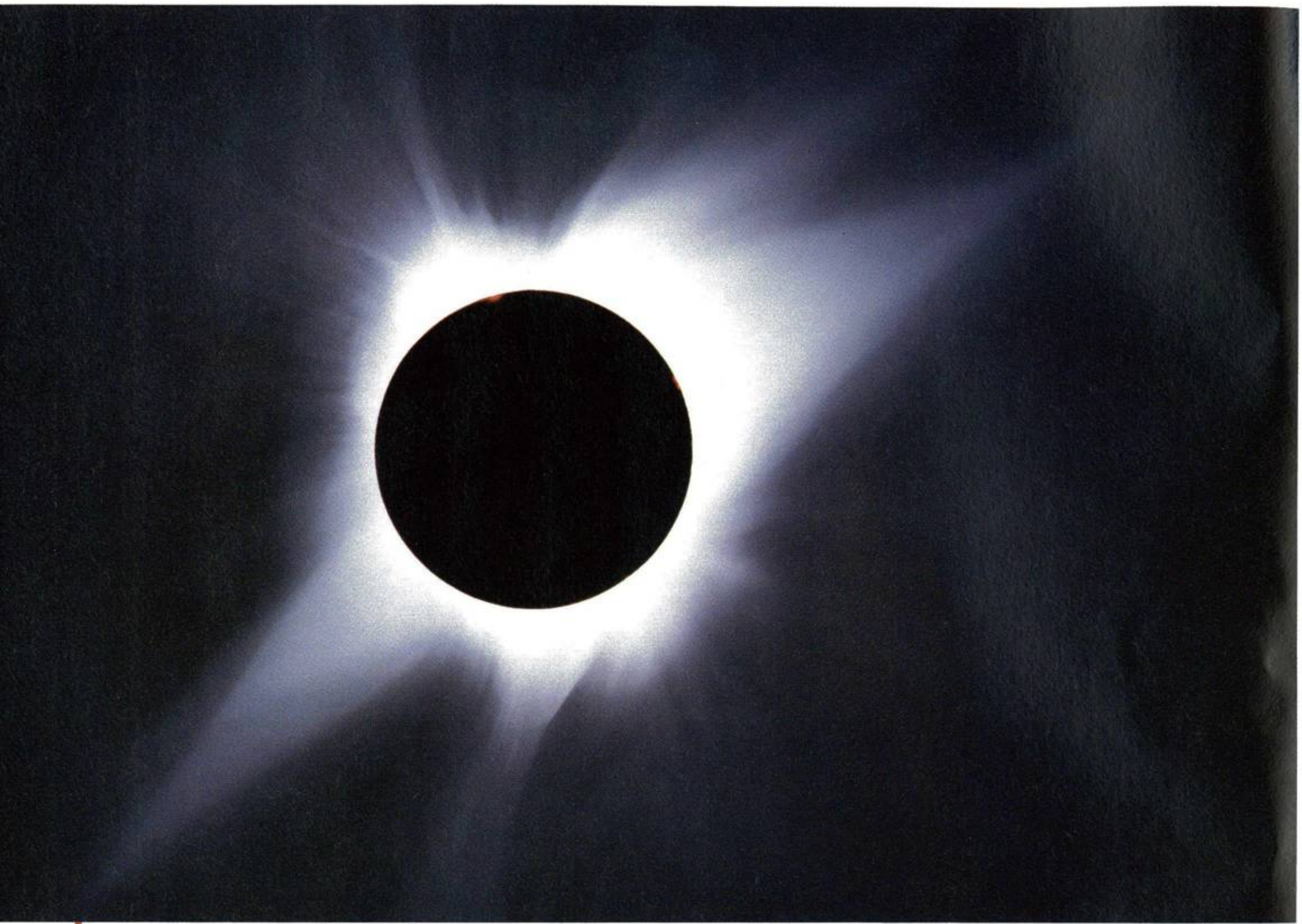


Roland Christen

80 The Secret of Taking Great Astrophotos

ON THE COVER

EXQUISITE DETAIL HIGHLIGHTS this large-format photo showing the Large Magellanic Cloud, the Milky Way's star-rich neighboring galaxy. For capturing the finest detail possible, nothing beats a medium-or large-format camera (see page 80). Photo by Luke Dodd.

36 New Discoveries on the Horizon

Next up for NASA's Discovery program: a mission to analyze the Moon's surface followed by another to probe Venus, the Sun, or interstellar dust. By Michael Carroll.

46 By the Light of Forgotten Suns

The ghostly remains of long dead stars highlight a new image of M31. By Jeff Kanipe.

48 Curtains at the Edge of the Universe

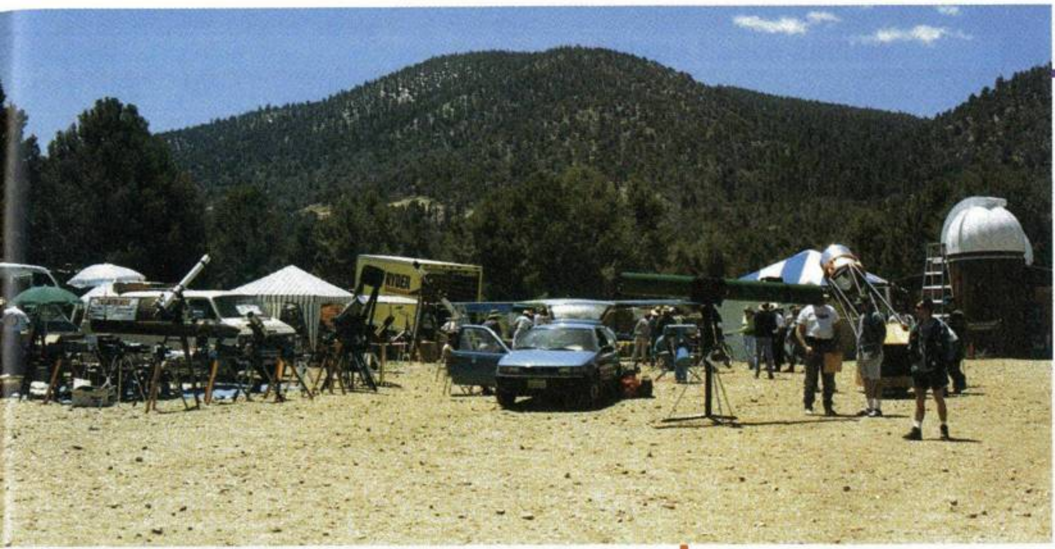
Astronomers hope that one day neutrinos and gravitons will help them "see" beyond the microwave background barrier. By Robert and Sarah Williams Scherrer.

54 Was Einstein Wrong?

An otherwise normal binary star seems to contradict relativity. By Robert Naeye.

62 Sky Almanac

The bright asteroid Iris cuts between the Pleiades and Hyades and a crescent Moon barely interferes with the Leonid meteor shower. By Deborah Byrd and Alister Ling.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72 Visit the Deep-Sky Zoo

Whether you view with the naked eye, binoculars, or a telescope, the sky offers many gaseous nebulae and star clusters that recall animals both exotic and familiar. By Edmund A. Fortier.

78 A Stunning Planetary Trio

A spectacular twilight gathering of Venus, Mars, and Jupiter awaits skygazers in this month's evening sky. By Richard Talcott.

COVER

80 Big on Celestial Photography

Dazzling, razor-sharp portraits of the heavens can be yours with a medium- or large-format camera. By Mark J. Coco and Scott W. Roberts.

86 Riverside Reflections

You can glimpse the future of our hobby by listening to amateurs and manufacturers who assembled at California's most popular star party. By John Shibley.

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BEHIND THE SCENES

Photography Rediscovered

Excuse me. I think something's going on that you ought to know about. Film-based astrophotography, given up for dead by many (and with glee by some), is showing strong signs of life. If the mail from readers is anything to judge by, conventional astrophotography is undergoing a renaissance. We've never seen such a wealth of images, in quantity or quality. What's behind all the activity?

Compared to CCD imaging, I think one plus for film is that it's drop-dead simple to get started with. Excellent film for recording the sky lies no farther away than your local drug store. And while commercial processing of celestial images has some pitfalls, these can usually be worked around. Then the gear itself is flexible — you can take pictures of the Painted Desert using the same camera you map the Milky Way with.

Jack Newton

And finally there's the big reason: The pictures are beautiful beyond words (see at left). Electronic imaging offers adventure... discovery... maybe even romance. But it doesn't — yet — offer breathtaking image quality. And that's still crucial for most sky shooters.

With this rebirth of interest in traditional astrophotography, ASTRONOMY is inaugurating a series of articles that will celebrate celestial images graven in silver, not silicon. These will vary from straightforward "how-to" stories to gorgeous showcases whose main purpose, frankly, is to whet your appetite. The first story in the series starts on page 80, and there'll be lots more to come.

Sincerely,

Robert Burnham

Robert Burnham
Editor
rburnham@astronomy.com

LETTERS

Computer Astronomy Comes of Age?

Your article on the Internet and astronomy, "Blasting along the Infobahn" (June 1995), struck a chord with me. I've used the CompuServe network several times and now enjoy it greatly with its enhanced service on the Net. I can communicate with other amateurs across the world without using snail-mail. It's exciting to click a mouse button and come out on the home page of the Anglo-Australian Observatory.

For me, however, astronomy is about going out into nature and listening to the sounds, watching the Milky Way, and photographing deep-sky objects. It's to see and hear how the new day starts as the Sun rises.

At our local observatory, nothing goes on without a computer. You cannot find an object without computer control. The observatory dome is controlled by a computer. Every few minutes the dome rotates slightly and club members need not know what star is this or that. What happens if the electricity fails?

Okay, professional astronomers need computers, but I think they should know where they are pointing the telescope without the aid of a machine. — *Stefan Beck, Stuttgart, Germany*

Unselfish Astronomy

Bob Cook's letter (June 1995) was amazing. If he really thinks that astronomy clubs are "a bunch of old guys, with few young people or women," we would like to invite him to come to St. Petersburg, Florida, and see what our club is all about.

The St. Petersburg Astronomy Club, wherein the women are strong, the men are good looking, and all the kids get As, is the oldest and largest astronomy group in the southeastern United States. Our club has met each month since 1927 and consists of 250 members.

(continued on (page 14)

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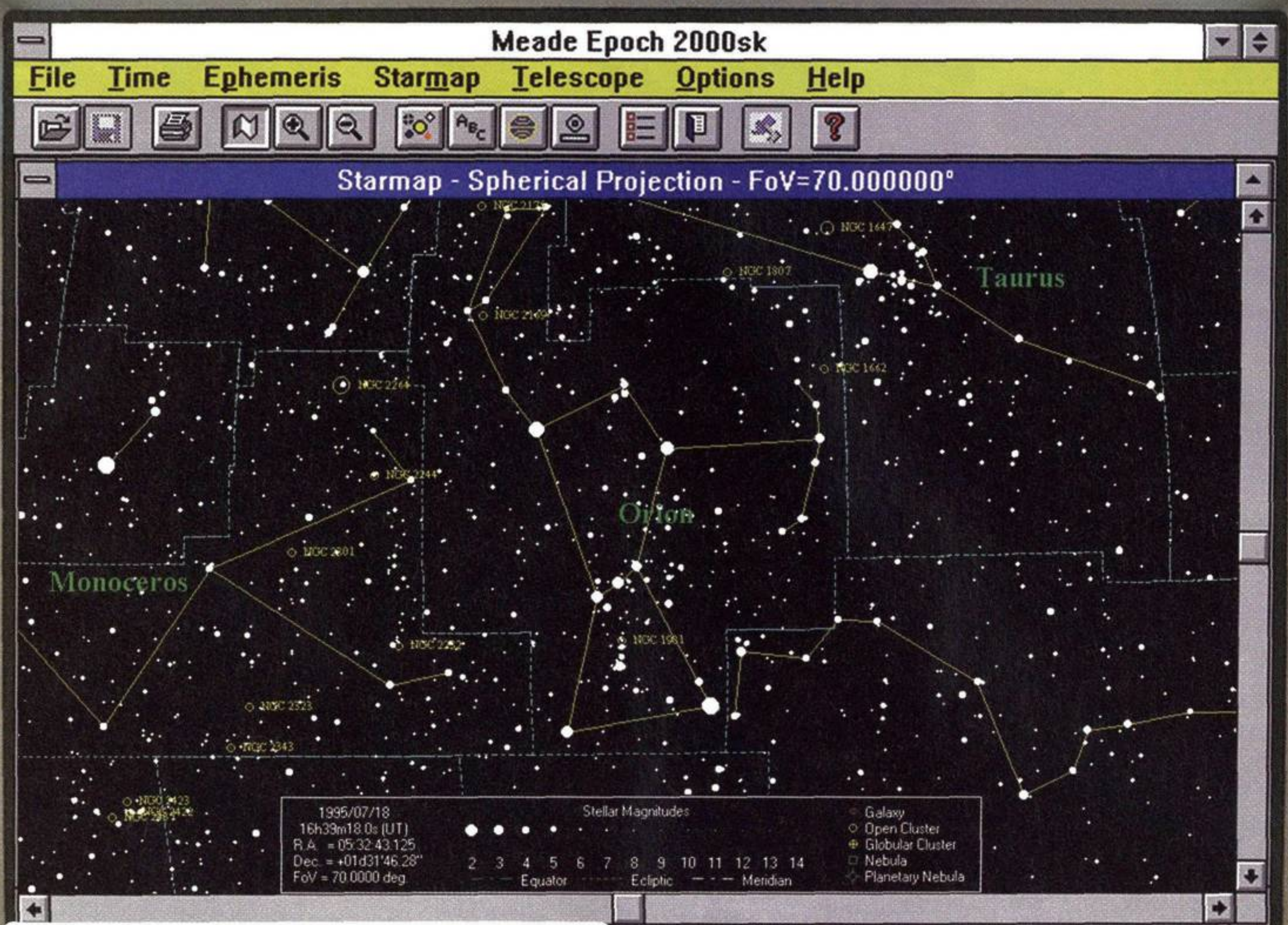
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Globular Cluster
Nebula
Planetary Nebula

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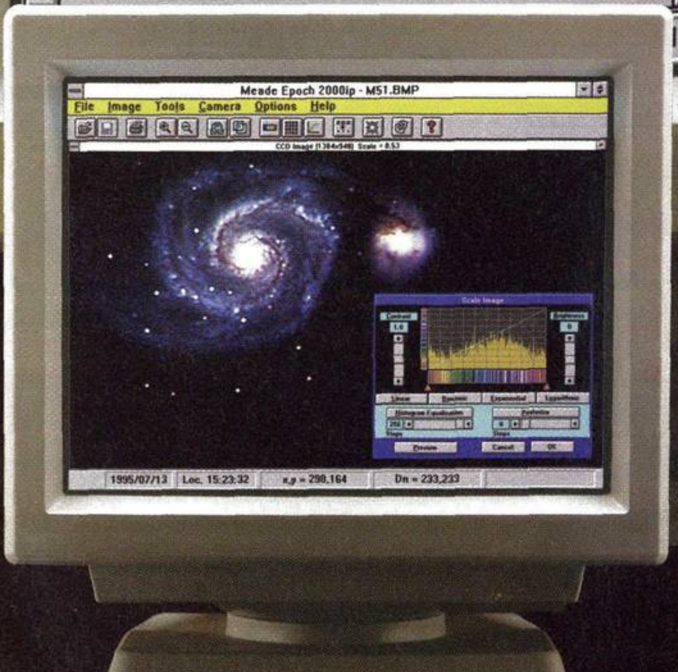
Epoch 2000sk *(above)* displays stars, planets, asteroids, and comets accurate in position to an *arc-second* level, the most precise position display of any sky software yet developed.


Meade Epoch 2000ip - M51.BMP
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EPOCH 2000ip Image Processing Software: Supplied on 3.5" discs for Windows 3.1 or higher **$199**

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The most powerful astronomical software ever made available can now be yours for only $149!

Now you can use the most precise sky software ever created, to zoom-in on telescopic fields **smaller than one arc second!** With star positions displayed as precisely as **0.01 arc second,** no longer is the Trapezium in Orion, for example, shown as a single point as in other software, **but as four precisely oriented starpoints, just as they appear in the telescope.** No longer do you need to guess the R.A. and Dec. of an object located away from the field center, as in other programs: Epoch 2000sk dynamically reads out the R.A. and Dec. of the cursor position anywhere in the field **and updates R.A. and Dec. instantaneously as the cursor is moved about the field.** LX200 owners can use Epoch 2000sk for remote auto-centering of objects in the telescopic field **to a precision of 30 arc seconds,** routinely!

Send for your free copy of **Meade Bulletin 2000.** See why, if you're serious about astronomy, Meade Epoch 2000sk is the only sky software to use!

EPOCH 2000sk Sky Software: 281,000 objects supplied on 3.5" discs for Windows 3.1 or higher **$149**

EPOCH 2000sk-CD Sky Software: 19 million objects, including the complete Hubble Guide Star Catalog; supplied on CD-ROM **179**

LX200 Interface Cable: for Meade LX200 operation by Epoch 2000sk . . **25**

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MEADE

TELESCOPES AND ACCESSORIES

Series 4000™ 2x Apochromatic Barlow Lens

#140: The most advanced Barlow lens available for commercial telescopes, the Meade #140 includes 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images absolutely unmatched in resolution, contrast and color correction. The #140 optically complements any telescope — refractor, reflector, or Schmidt-Cassegrain. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm.

$79.95 (3.29)

Series 4000™ Super Plössls 52°

Meade 4-element Super Plössls, updated and redesigned to utilize the latest in optical glass-types, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or for deep-space; guaranteed to deliver more contrast and image sharpness than any other brand. Rubber eyeguards fold down for eyeglass wearers–a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal.

Super Plössls (SP; 4-elements; 1.25"; 52°):

6.4, 9.7, 12.4, 15, 20, 26mm each: **$87.95** (3.45)

32mm (52°); **40mm** (44°) each: **109.95** (3.79)

56mm (52°; 2") **229.95** (5.48)

Series 4000™ f/6.3 Focal Reducer/ Field Flattener

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture.

$129.95 (3.60)

World's Most Advanced Illuminated Reticle Eyepiece

Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. **Internal batteries included.** Multi-coated optics. Bullseye reticle. 1.25"

$149.95 (3.45)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator.

$129.95 (3.45)

Series 4000™ Super Wide Angle 67°

For exquisite wide-angle images at low-to-medium powers, ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8, 18, and 24.5mm are superb complements to the #140 Barlow, above.

Super Wide Angle (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $159.95** (3.49); **18mm: 169.95** (3.69); **24.5mm: 199.95** (3.89); **32mm** (2"): **279.95** (4.78); **40mm** (2"): **339.95** (5.48)

Series 4000™ Ultra Wide Angle 84°

The ultimate eyepieces; extreme image sharpness over an amazing 84° field.

Ultra Wide Angle (UWA; 8-elements; 1.25"; 84°)–**4.7mm: $179.95** (3.29); **6.7mm: 219.95** (3.29); **8.8mm** (1.25"/2"): **269.95** (4.78); **14mm** (1.25"/2"): **329.95** (5.48)

Camera Adapters

Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

.965": $27.95; **1.25": $29.95** (2.98)

Variable-Projection Camera Adapter (1.25")

Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera.

$39.95 (2.98)

Variable Tele-Extender

For eyepiece-projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Sliding cell with lock permits wide range of projection magnifications with the same eyepiece. Use with T-mount for your camera.

$39.95 (2.98)

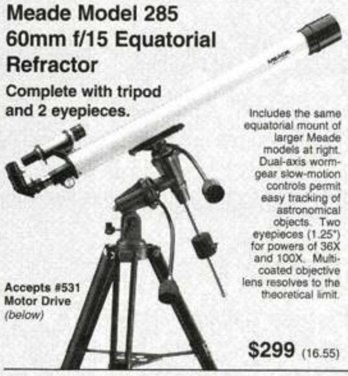
T-Adapters for SCT's

Rigidly couples camera to telescope for prime focus photography with any Meade or Celestron Schmidt-Cassegrain. Use with T-Mount for your 35mm camera.

$26.95 (2.98)

Meade Model 285 60mm f/15 Equatorial Refractor

Complete with tripod and 2 eyepieces.



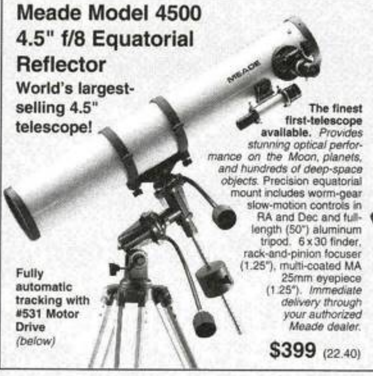
Includes the same equatorial mount of larger Meade models at right. Dual-axis worm-gear slow-motion controls permit easy tracking of astronomical objects. Two eyepieces (1.25") for powers of 36X and 100X. Multi-coated objective lens resolves to the theoretical limit.

Accepts #531 Motor Drive *(below)*

$299 (16.55)

Meade Model 4500 4.5" f/8 Equatorial Reflector

World's largest-selling 4.5" telescope!



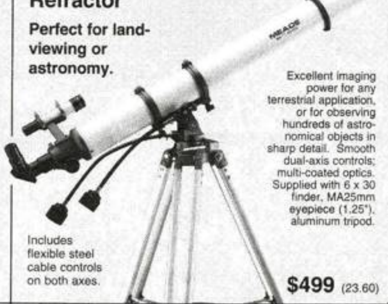
The finest first-telescope available. *Provides stunning optical performance on the Moon, planets, and hundreds of deep-space objects.* Precision equatorial mount includes worm-gear slow-motion controls in RA and Dec and full-length (50") aluminum tripod. 6 x 30 finder, rack-and-pinion focuser (1.25"), multi-coated MA 25mm eyepiece (1.25"). *Immediate delivery through your authorized Meade dealer.*

Fully automatic tracking with #531 Motor Drive *(below)*

$399 (22.40)

Meade Model 390 90mm f/11 Altazimuth Refractor

Perfect for land-viewing or astronomy.



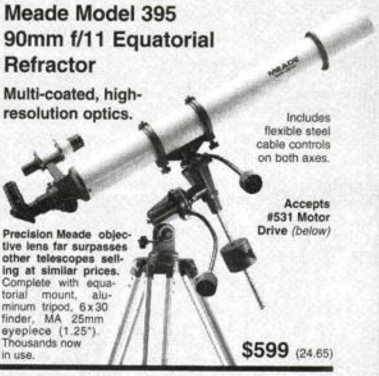
Excellent imaging power for any terrestrial application, or for observing hundreds of astronomical objects in sharp detail. Smooth dual-axis controls; multi-coated optics. Supplied with 6 x 30 finder, MA25mm eyepiece (1.25"), aluminum tripod.

Includes flexible steel cable controls on both axes.

$499 (23.60)

Meade Model 395 90mm f/11 Equatorial Refractor

Multi-coated, high-resolution optics.



Includes flexible steel cable controls on both axes.

Accepts #531 Motor Drive *(below)*

Precision Meade objective lens far surpasses other telescopes selling at similar prices. Complete with equatorial mount, aluminum tripod, 6 x 30 finder, MA 25mm eyepiece (1.25"). Thousands now in use.

$599 (24.65)

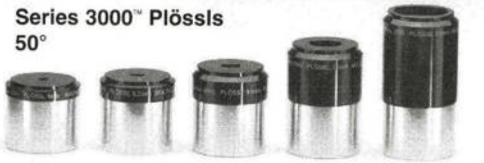
Meade intermediate-size telescopes are the world's largest-selling quality telescopes of their apertures. *They are the only telescopes in this price range designed by Meade engineers and manufactured to exclusive Meade specifications.* Each instrument includes mechanical components, gear systems, and accessories specifically intended for serious applications of the beginning to intermediate amateur astronomer. American-size 1.25" barrel-diameter eyepieces, threaded for filters, are included with all models. Large cable controls facilitate the tracking of astronomical or terrestrial objects, and, on equatorial models, the optional Meade #531 Motor Drive *(see right)* enables fully automatic tracking of astronomical objects.

#531 Motor Drive

Attaches in seconds to the equatorial mounts of Meade Models 285, 4500 or 395 telescopes. Permits fully automatic tracking of celestial objects. Cordless operation anywhere in the world from 3 (user-supplied) AA batteries.

$99.50 (4.78)

Series 3000™ Plössls 50°



The very latest in eyepieces from Meade optical designers, new Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Available in a wide range of focal lengths from 5mm through 25mm. All five eyepieces are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. Manufactured exclusively for Meade Instruments by one of Japan's leading lensmakers, Series 3000 Plössls produce excellent results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

Series 3000 Plössls (4-elements; 1.25"; 50°)

5, 6.7, 9.5, 16, 25mm each: **$49.95** (3.45)

Series 3000™ Plössl 40mm 44°

A perfect complement to the Series 3000 Plössls at left, this all-new Plössl 40mm produces spectacular low-power, wide-field results with any telescope. Includes classical 4-element Plössl optics, multi-coated. Barrel dia. 1.25"; threaded for filters. Apparent field: 44°.

$79.95 (3.79)

MA12mm Illuminated Reticle Eyepiece

Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle. Wireless red LED illuminator and variable brightness control. **Batteries included.**

$99.95 (3.45)

As above but with 6 ft. cord and plug for Meade telescopes with power panels, in place of wireless illuminator. **$79.95** (3.45)

Modified Achromatic Eyepieces

Meade 3-element MA eyepieces yield sharp, well-corrected images on the Moon, planets, and deep-space at a reasonable price. Multi-coated; threaded for filters; 1.25" barrel diameter. Apparent field: 40°. **MA 9, 12, 25, 40mm.**

each: **$37.95** (2.98)

2x-3x Variable Barlow (1.25")

#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25".

$59.95 (3.45)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of the #122, at right. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated.

$47.95 (3.45)

2x Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25"

$47.95 (3.45)

HOW TO ORDER

- Prices shown are suggested USA mail-order retail prices and do not include any applicable sales taxes.
- Suggested shipping and handling charges to the 48 states by UPS or US Mail shown in ( ) next to each price.
- Meade accessories may be ordered from any Meade Advanced Products Dealer. **The following national mail-order dealers carry all Meade accessories in-stock for immediate shipment:**

ASTRONOMICS, Norman, OK.
Orders: 800-422-7876; Info.: 405-364-0858.

CALIFORNIA TELESCOPE CO., Burbank, CA.
Orders & Information: 818-505-8424.

CITY CAMERA, Dearborn, MI.
Orders: 800-359-5085; Info.: 313-846-3922.

FOCUS CAMERA, Brooklyn, NY.
Orders: 800-221-0828; Info.: 718-436-6262.

LUMICON, Livermore, CA.
Orders: 800-767-9576; Info.: 510-447-9570.

SHUTAN CAMERA & VIDEO, Chicago, IL.
Orders: 800-621-2248; Info/IL: 312-332-2000.

Canada:

EFSTONSCIENCE, Toronto, Ontario.
Orders & Information: 416-787-4581.

KHAN SCOPE CENTRE, Toronto, Ontario.
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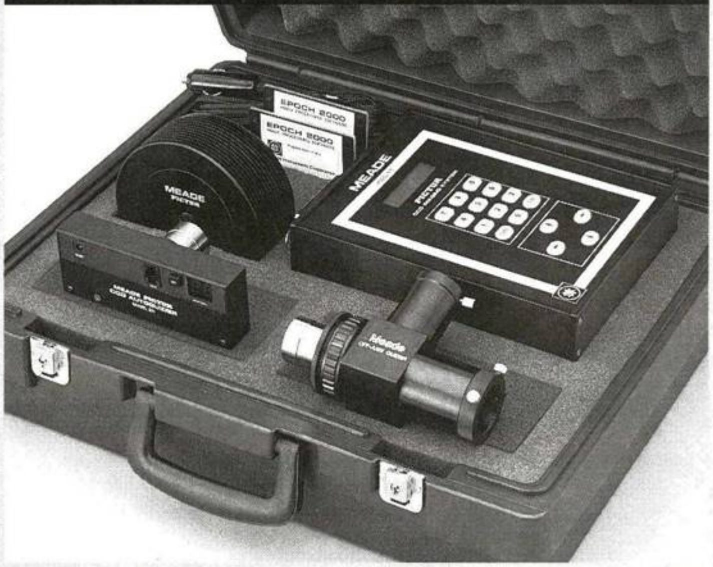
FREE! $800 CCD Equipment System!

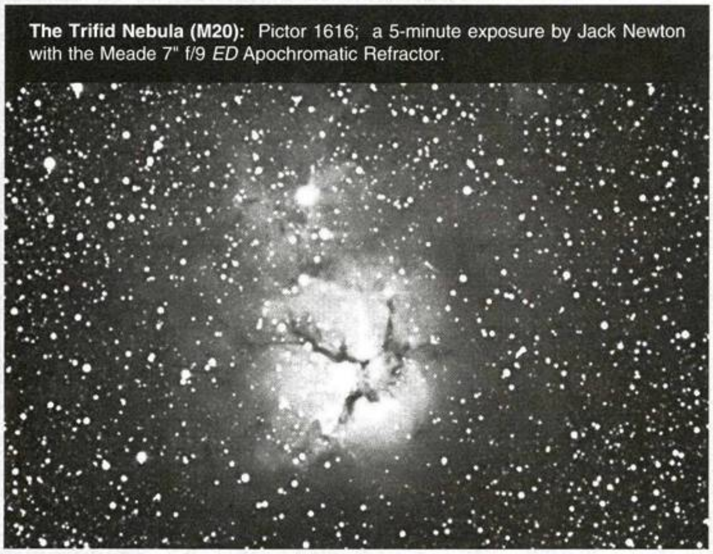
Now, for a limited time, when you purchase a Meade Pictor 416 or 1616 CCD imager at the regular price, **we'll include an $800 Meade CCD Equipment System—everything you need for advanced CCD imaging—absolutely FREE!** Purchased separately, the CCD Equipment System is priced at $807 and includes these important products:

Meade Pictor 201 Autoguider: Allows completely automatic guiding of your Pictor camera during CCD imaging or your 35mm camera during long-exposure astrophotography.	**$395.**
Meade CCD Off-Axis Guider System: Complete with adapters for 1.25" eyepiece holders and for Schmidt-Cassegrain rear-cell threads. Use with the Pictor 201 on guide stars to 10th-magnitude.	**119.**
Meade CCD Image-Orientation Adapter: Threads into the Off-Axis Guider and permits precise image orientation on the CCD chip.	**35.**
Meade Epoch 2000ip Image Processing Software: Professional Windows-based image processing that permits the enhancement and analysis of CCD images using the most advanced techniques, including dynamic scaling, histogram equalization, image convolution, unsharp masking, median filtering, RGB merging, and more.	**199.**
Meade Foam-Lined Carrying Case (19" x 14" x 7"): Provides for secure storage and transport of your Pictor 416 or 1616 CCD imager as well as all items of the CCD Equipment System described above.	**59.**
Total price of all items if purchased separately:	**$807.**

The Meade Pictor 416 CCD Imaging Camera is packed, at no additional charge, with the **Meade $800 CCD Equipment System** during the period of this special offer.

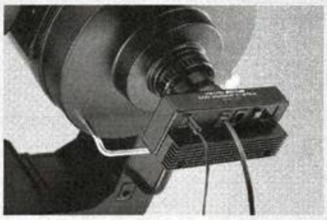


The Trifid Nebula (M20): Pictor 1616; a 5-minute exposure by Jack Newton with the Meade 7" f/9 *ED* Apochromatic Refractor.



Pictor 201 Autoguider: For flawless, ultraprecise autoguiding during long-exposure astrophotography or CCD imaging. Automatically locks on to guide stars as faint as 10th-magnitude and makes all required dual-axis corrections. Results in perfectly guided astrophotographs or CCD images during even the longest of exposures. Completely self-contained; no host PC required. **$395.** + $10 packing & shipping in 48 states.

Pictor 208 Autoguider/Imager: For an amazingly low price, the 208 gives impressive imaging capability even to the novice. On telescopes of 4" aperture and larger, the Pictor 208 yields very satisfying results and, in addition, is a full-capability autoguider, containing the exact same autoguider hardware and software as the Pictor 201, above. The 208 incorporates the Texas Instruments TC-255 microchip, by far the largest, highest-resolution chip available in any CCD unit in its price range. **$795.** + $15 P & S



Pictor 216 CCD Autoguider/Imager: Identical in operation and size to the 208, the Pictor 216 includes a 16-bit A/D converter for 65,536 brightness levels. The result is a level of image quality only obtainable on competing units that sell for almost twice the 216's price. Combining high-resolution imaging with low dark current, the Pictor 216 satisfies the long-term CCD imaging requirements of the majority of serious amateurs. **$1295.** + $15 P & S

Pictor 416 CCD Autoguider/Imager: Armed with the powerful Kodak KAF-0400 CCD microchip, the Pictor 416 is the most advanced high-resolution CCD system available under $5000. And, with its standard-equipment SCSI interface, the 416 can full-frame download in *one second!* The Pictor 416 is a powerful CCD system on any telescope; attached to a Meade LX200, its capabilities are truly awesome. The auto-mosaic feature, for example, permits the imaging of an arbitrarily large sky area **automatically** on user command. **$2495.** + $25 P & S

Pictor 1616 Autoguider/Imager: For professional-level applications the Pictor 1616 utilizes the Kodak KAF-1600 microchip, one of the largest (13.80 x 9.20mm) CCD chips in commercial production. Identical in pixel density and dark current to the 416, but with *four times* the chip area, the 1616 permits the imaging of very large sky areas: a sky area of 23' x 15' with an 8" f/10 Schmidt-Cassegrain, almost one-half the lunar surface in a single exposure. The 1616 is the finest CCD imaging system available at under-$10,000. **$6495.** + $40 P & S

The special Meade CCD Equipment System offer is effective beginning July 20, 1995, at participating Meade dealers in the U.S.A. and Canada. *This offer is valid until further notice and may be withdrawn at any time.* ■ All prices shown are suggested U.S. national mail-order retail prices, exclusive of sales taxes or credit card charges, if applicable. ■ For safety reasons AC-powered personal computers should be used indoors only. ■ The Meade brochure ***CCD Imaging Made Simple*** is available free of charge, or send $3.00 for the 76-page **Meade *1995 General Catalog.***

AUTHORIZED U.S. MAIL-ORDER DEALERS

ASTRONOMICS, Norman, OK, Orders: 800-422-7876; Information: 405-364-0858

CALIFORNIA TELESCOPE COMPANY, Burbank, CA
Orders & Information: 818-505-8424

CITY CAMERA, Dearborn, MI, Orders: 800-359-5085; Information: 313-846-3922

FOCUS CAMERA, Brooklyn, NY, Orders: 800-221-0828; Information: 718-436-6262

LUMICON, Livermore, CA, Orders: 800-767-9576; Information: 510-447-9570

SHUTAN CAMERA & VIDEO, Chicago, IL, Orders: 800-621-2248;
Illinois & Information: 312-332-2000

Canada:

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KHAN SCOPE CENTRE, Toronto, Ontario, Orders & Information: 416-783-4140

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World's Leading Manufacturer of Astronomical Telescopes for the Serious Amateur
16542 Millikan Avenue, Irvine, Calif. 92714
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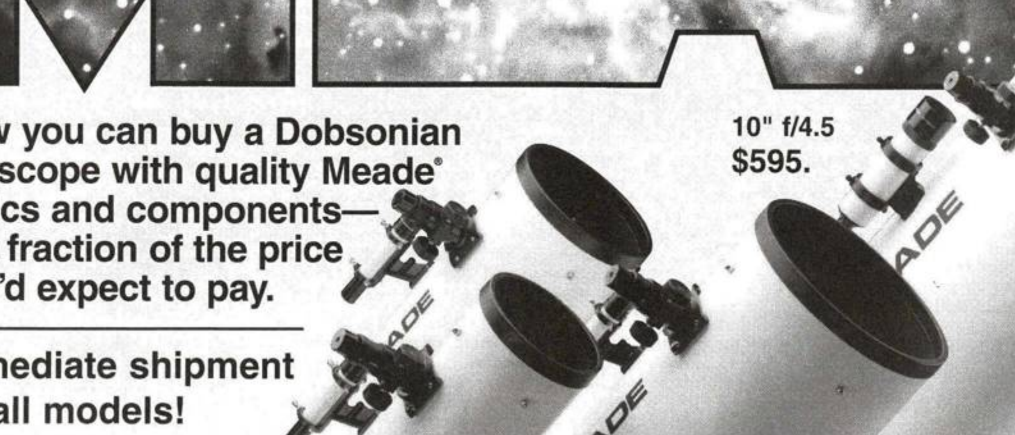
STARFINDER™ DOBSONIANS

Now you can buy a Dobsonian telescope with quality Meade® optics and components—at a fraction of the price you'd expect to pay.

Immediate shipment on all models!



10" f/4.5
$595.

12.5" f/4.8
$795.

8" f/6
$425.

Shown with optional #637 6 x 30mm or #545 8 x 50mm Viewfinders

6" f/8
$325.

SPECIAL ACCESSORY OFFER!

At the time you order any Starfinder 6", 8", 10", 12.5", or 16" Dobsonian Telescope, you can buy **two additional Meade multi-coated Modified Achromatic MA9mm and 12mm eyepieces *and* the Meade #637 6 x 30mm coated achromatic viewfinder with metal bracket for a *total* of only $49.95! Purchased separately, the 2 additional eyepieces and viewfinder sell for $125.85!** *(Shown in photo: MA9mm, MA12mm, and standard-equipment MA25mm eyepieces, with #637 6 x 30mm viewfinder.)* Offer valid until further notice.

Starfinder Dobsonian 16

New Low Price! 16" f/4.5 $895!

Immediate Shipment!

The only popularly-priced 16" Dobsonian with Pyrex® mirrors as standard equipment.

Includes 1.25" rack-and-pinion focuser; shown with optional 8 x 50mm viewfinder.

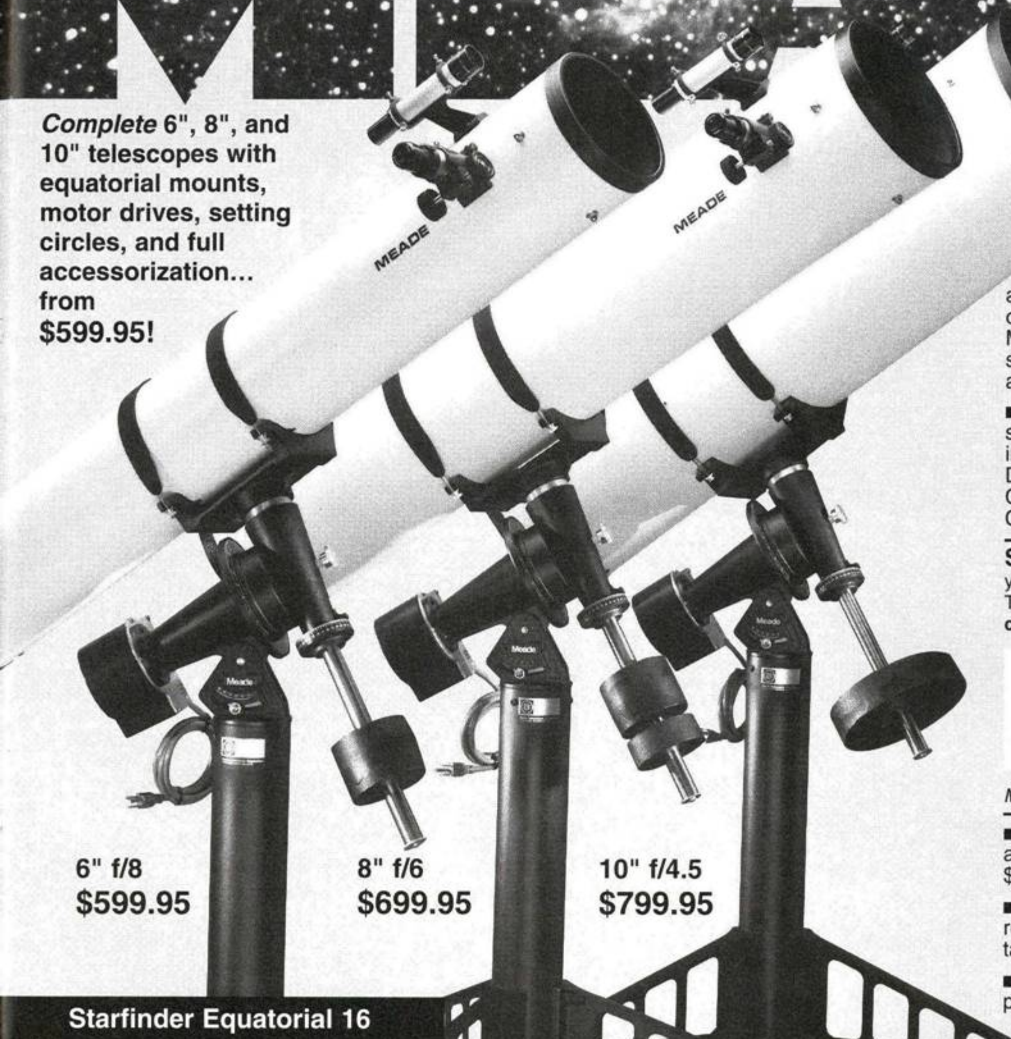
Compare Meade Starfinders *feature-for-feature* with other similarly priced Dobsonians!

- **Primary and Secondary Mirrors of Low-Expansion Pyrex® glass!** Unlike the plate-glass optics of other Dobsonians that can become thermally unstable (especially in larger apertures), Meade Dobsonians include the *exact same* professional-quality Grade-A, fine-annealed Pyrex® optical systems used on Meade Starfinder Equatorial Reflectors. Optics that meet the theoretical limits of resolution for their apertures.
- **Precision Rack-and-Pinion Focuser!** An industry-standard full-size rack-and-pinion system with 2.6" of focus travel.
- **Fully-Adjustable 4-vane Secondary Mirror Systems!** *Rigid 4-vane systems* that permit precision alignment of the secondary mirror to the primary mirror.
- **Rigid, Durable, Beautiful Dobsonian Mountings!** Mountings that provide extremely smooth motions of the telescope in both altitude and azimuth. Both telescope axes ride on zero-backlash Teflon/Nylon bearings, facilitating the location and tracking of celestial objects anywhere in the sky. Each mount is manufactured of cabinet-quality materials and designed for a lifetime of use. Handles are provided for easy portability.
- **Optical Tubes:** Starfinder Dobsonians include the same strong, spiral-wound optical tubes used on Starfinder Equatorials *(facing page)*. All telescopes include a multi-coated MA25mm eyepiece as standard equipment. Each tube is factory pre-drilled for the optional 6 x 30mm or 8 x 50mm viewfinder.
- **Performance!** A Meade Starfinder Dobsonian or Equatorial Telescope opens up the skies to an extremely wide range of serious visual observing: all 110 Messier objects, thousands of NGC objects–nebulae, galaxies, star clusters, in all their variations of form, color, and extent, as well as the Moon and planets in stunning, high-resolution detail. Starfinder Dobsonians are telescopes for visual observing; motor-driven Starfinder Equatorials may be used, in addition, for lunar and planetary photography and even for limited deep-space astrophotography.
- **Packing and UPS Shipping Charges:** to any address in the 48 states: 6"–$39; 8"–$49; 10"–$69; 12.5"–$79. 16"–$45 packing, shipped truck freight collect.
- **To Order:** Contact one of the authorized mail-order dealers on the facing page.

MEADE

STARFINDER™ EQUATORIALS

Complete 6", 8", and 10" telescopes with equatorial mounts, motor drives, setting circles, and full accessorization... from $599.95!



6" f/8
$599.95

8" f/6
$699.95

10" f/4.5
$799.95

- **Electric Motor Drive** (115v/60Hz) with 6 ft power cord: permits **fully automatic** tracking of celestial objects; plugs into any standard outlet.
- **Standard Accessories and Components:** Precision Rack-and-Pinion Focuser (1.25") with full 2.6" travel; coated achromatic #637 6 x 30mm Viewfinder with crosshair eyepiece and 7° field; multi-coated MA25mm (1.25") eyepiece, threaded for filters; strong, durable, spiral-wound optical tube with attractive white finish.
- **Optional Accessories:** See the Meade accessories ad in this issue. Additional systems, including #55 Manual Declination Control, #43 Drive Corrector, and #47M Dual-Axis Drive Corrector, are described in the Meade General Catalog.

SPECIAL ACCESSORY OFFER! At the time you order any Starfinder 6", 8", 10", or 16" Equatorial Telescope, you can buy **two additional Meade multi-coated Modified Achromatic MA9mm and 12mm eyepieces for a _total_ of $29.95! Purchased separately, the two additional eyepieces sell for $75.90.** *(Shown in photo: MA9mm, MA12mm, and standard-equipment MA25mm eyepieces.)* Offer valid until further notice.

- **Packing and UPS Shipping Charges:** to any address in the 48 states: 6"–$65; 8"–$75; 10"–$90. 16"–$55 packing, shipped truck freight collect.
- All prices shown are suggested USA mail-order retail prices, not including any applicable sales taxes.
- **Meade 1995 General Catalog** — $3.00 postpaid—is available from any authorized Meade dealer or directly from Meade Instruments.
- For further information call Meade Instruments at 714-756-2291 or contact one of these authorized mail-order dealers:

ASTRONOMICS, Norman, OK.
Orders: 800-422-7876; Info.: 405-364-0858.

CALIFORNIA TELESCOPE COMPANY, Burbank, CA.
Orders & Information: 818-505-8424.

CITY CAMERA, Dearborn, MI.
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FOCUS CAMERA, Brooklyn, NY.
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Orders: 800-767-9576; Info.: 510-447-9570.

SHUTAN CAMERA & VIDEO, Chicago, IL.
Orders: 800-621-2248; Illinois & Info.: 312-332-2000.

Canada:
EFSTONSCIENCE, Toronto, Ontario.
Orders & Information: 416-787-4581.

KHAN SCOPE CENTRE, Toronto, Ontario.
Orders & Information: 416-783-4140.

Starfinder Equatorial 16

16" f/4.5
$2495.

See the Meade General Catalog for details.

Includes 8 x 50mm viewfinder and giant #682 focuser.

Shown with optional Dual-Axis Drive Corrector.

Standard equipment on 6", 8", and 10" models includes:

- **Superb Optical System:** Includes hand-figured parabolic primary mirror that meets the theoretical limit of resolution for its aperture, with matching elliptical flat secondary mirror. Both mirrors multi-coated and made of low-expansion, Grade A, fine-annealed Pyrex® glass.
- **Precision Equatorial Mount:** Manufactured of machined aluminum to tolerances of .001" or better, with 4"-dia. pier and die-cast tripod legs, for rock-solid support of the optical tube. The telescope moves effortlessly from object-to-object on precision bearing surfaces. Polar and declination shafts are 1" solid steel. Setting circles on both axes facilitate the location of faint objects directly from their catalogued coordinates.

A D V A N C E D P R O D U C T S D I V I S I O N

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World's Leading Manufacturer of Astronomical Telescopes for the Serious Amateur

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MEADE
MEADE 127ED/APO EMC
Meade LXD 650

Meade Model 127ED:
5" *ED* Apochromatic Refractor.
Shown with optional #1697
Computer Drive System.

Background image: **the Omega Nebula (M17) —**
A 5-minute image by Jack Newton using the
Meade 7" *ED* Apochromatic Refractor and Meade
Pictor 1616 CCD Imager.

ED APOCHROMATIC REFRACTORS

"This is the best black-and-white CCD image of M17 that I have ever taken with any telescope. I just couldn't believe that this could be done in a 5-minute shot with a CCD camera and a 7" refractor. I'm amazed at how the telescope performs, even against my own 25" Newtonian." **—Jack Newton**

Fortunate indeed is the observer with a Meade *ED* Apochromatic Refractor at his or her disposal, for these are professional-class instruments capable of serious research. Observe structural detail and color variations within Jupiter's Red Spot and at the boundaries of 8 to 10 cloud belts; resolve all three of Saturn's main rings and substructures within the rings themselves. *Simply put, if you're looking for the finest, textbook-perfect, ultra-high-resolution, high-contrast imaging of the skies that astronomical instrumentation, of any type, can provide, then a Meade ED Apochromatic Refractor is for you.*

Use the massive Meade **LXD 650** (4", 5") or **LXD 750** (6", 7") equatorial mounts in conjunction with the optional **#1697 Computer Drive System** to slew the telescope across the sky and computer-point the instrument, automatically, *to a precision of one arc-minute.* ***Meade LXD mounts are the only commercially-available German-type mounts capable of such a feat.*** Actuate any of 9 pushbutton-controlled drive speeds (from 2x photoguide to 8°/sec. fast-slew) on both axes, automatically, to locate and center any object directly from its input R.A. and Dec. Or use the onboard database for even faster object centering. Included with the #1697 CDS, the Meade **Smart Drive**™ assures the extremely low periodic error essential to research-level photographic or CCD imaging.

More than 40 Meade optional accessories are available to suit virtually any observing, photographic, or CCD imaging requirement.

Supplied complete per catalog specifications:

4" f/9 Model 102ED	**$2495.**
5" f/9 Model 127ED	**2995.**
6" f/9 Model 152ED	**4495.**
7" f/9 Model 178ED	**5495.**
#1697 Computer Drive System	**695.**

Packing and shipping in the 48 states: 4"—$105; 5"—$125; 6"—$185; 7"—$215.

MEADE
MEADE LX200
MEADE LX200 EMC
MEADE LX200

16" LX200

Professional instrumentation for the demanding school, college, or university research program—or as the ultimate personal telescope for the advanced amateur.

Professional-grade 16" f/10 optical system meets or exceeds advanced requirements; includes BK7 correcting plate for high UV transmission and EMC super multi-coatings. ■ **Massive one-piece fork mount** permits substantial auxiliary equipment to be piggybacked with rock-solid stability. ■ **Large 11" worm gears** on both axes, with factory-programmed Smart Drive™; periodic error less than 5 arc seconds. ■ **Automatic GO TO capability** to any object in the onboard 64,350-object database or to any input R.A. and Dec. ■ **High-Precision Pointing™** to within one arc-minute in the GO TO mode. ■ **DC servo drive systems** with integrated encoders and planetary gearboxes; encoder resolution: 0.13 arc secs. ■ **Six pushbutton-controlled drive-speed rates,** from photo-guide to fast-slew on both axes, simultaneously. ■ **Micro-processor controlled sidereal-rate tracking** in AZ or EQ modes with quartz accuracy. ■ **Home-Pulse Acquisition** permitting remote alignment and operation through a modem link to the telescope's RS-232 interface. ■ **Control panel connectors** for optional systems including CCD autoguiders and imagers, electric focuser, and the Meade **#1222 Field De-rotater** for long-exposure astrophotography in the AZ mode. ■ Available with **supergiant transportable field tripod** (2-person field set-up in less than 10 minutes); **permanent altazimuth pier** (permitting the entire instrument to be housed in a 2-meter dome); or **permanent equatorial pier** (in cases where piggybacked astrocameras do not permit field de-rotation).

The Meade 16" LX200 is in continuous production at the Meade Irvine, Calif. factory. **Delivery time:** 4 to 12 weeks. **Price:** $14,950, complete with supergiant field tripod, plus $385 packing and shipping in the 48 states; prices slightly higher with permanent altazimuth or equatorial pier.

For your copy of the all-new **1995 Meade General Catalog** ($3.00), write Meade Instruments or contact your authorized Meade Advanced Products Dealer.

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Meade Instruments is pleased to recommend the authorized Meade dealers on these pages for your telescope-buying requirements. Whether you're looking for a quality entry-level telescope at under-$200, a fully equipped professional instrument at over-$5000, or one of more than 2 dozen models in between, there's a Meade telescope that's right for your budget and applications.

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LETTERS

We pride ourselves on helping newcomers get started with touring the night sky. We hold public viewings of the planets to introduce people to astronomy. We had many people from ages 5 to 75 at our latest Jupiter Watch. If Mr. Cook says he won't join a club and become a "boring intellectual," we submit he hasn't found the right club. — *Nancy and Bill Huff, Tampa, Florida*

Obviously Mr. Cook's experience with astronomy clubs has been limited. I am a beginner in the world of astronomy and my experiences have all been positive. My husband and I were welcomed with open arms into the local astronomy society, the Midlands Astronomy Club in Columbia, South Carolina. Members have shared their expertise and have provided dark sky sites from which to view the heavens.

Our first star party almost ended in frustration as dew fogged our scope. Not wanting to burden the experienced members, we began to pack up. Club member Bob Maxwell encouraged us to stay. For the rest of the evening we got a personalized tour through his 20-inch Dobsonian and unlimited access to a pair of 80mm binoculars.

It seems like the club in Mr. Cook's area just wasn't what he was looking for. That being the case, however, don't generalize and lump all astronomy clubs into one category. They're as varied as the night sky. — *Monica Wyrick, West Columbia, South Carolina*

Bursts of Black?

As an avid astronomy buff interested in battling the ever-increasing problem of light pollution, I was dismayed at the recent suggestion of Tom Bemus of the Martz Observatory (Letters, July 1995). Bemus's suggestion that backyard astronomers coordinate bursts of camera flashes to signal the Shuttle/Mir flyover was disappointing.

As a constructive alternative, why not turn off our lights as a signal to persons in low-Earth orbit? Not only would an area-wide turn-off be as noticeable to the overflying astronauts, but it would give some small gain of dark sky to local astronomers on the ground, not to mention saving electricity costs and reducing the demands on an already overburdened power system. — *John T. Smith, Honolulu, Hawaii*

A Blockhead Theory

I was devastated when I read the letter by Jim Whitehouse about conventional photographs versus CCDs (May 1995). Whitehouse defended the little squares in CCD images by revealing that the universe consists of little blocks. My whole view of the universe was destroyed.

At first, I thought the new theory I had proposed, that CCD imagery shows the basic building blocks of the universe, was bogus. After the initial shock, I've reconsidered. Of course stars may be squares built from these basic blocks. As for planets, they may appear round, but this is due to the offset of the basic blocks by convenient random placement over time.

I have it on the authority of Elvis (who hovered in my backyard last week) that this secret will unleash the dawning of a new era in science as astronomers discover his image formed by a little clump of blocks in a CCD image of part of the Dumbbell Nebula. — *John Phillips, Sandy, Oregon*

Another Minor Planet Source

I want to thank you for "Find a Rock in Space" by Mark Coco (August 1995). One of the reasons I subscribe to ASTRONOMY is its superior coverage of minor planets. Mr. Coco's statement that "the numbers preceding the asteroid names refer to their order of discovery" is mostly but not strictly correct. The rule fails for more recent discoveries. A look through recent *Minor Planet Circulars* shows that some asteroids were given preliminary designations that lasted many years before finally receiving a number and others received a number two years or less after their discoveries.

Mr. Coco mentioned several sources to help with asteroid observing, none of which provide finder charts. Each month for the past six years I have published the *Minor Planet Observer*, which now features up to 20 charts for asteroids reaching opposition in a given month along with occasional news notes and letters and articles from readers. *MPO* also offers "asteroiding awards," certificates for those who visually or photographically observe at least 50 asteroids.

Subscriptions to the *MPO* are $15 per year for the United States, Canada, and Mexico, and $25 per year elsewhere. — *Brian D. Warner, P.O. Box 818, Florissant, CO 80816* ☐

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Enjoying Astronomy Despite Everything Else

Ray Grasshoff

For me, the realization that I had lost touch with astronomy, a hobby that had been part of my life for most of my 40 years, came with a friend's passing remark. "Mars is in the morning sky." Oh yeah. That out-of-place "star" I saw in the constellation of Gemini as I picked up the newspaper this morning. Ouch! That hadn't even occurred to me.

What happened? How did I get so out of touch? I still had the equipment — not one telescope, but three — and a pair of binoculars that I used almost exclusively for astronomy. But when was the last time I had used them? I thought back to an evening more than a year ago when I had joined other amateurs at a Lions Club fundraiser. Was that really the last time? Why had it been so long? Soul searching began in earnest.

My interest in astronomy took root about the time I was a junior high school kid in a small Texas town, population about 2,300. I took a not-uncommon path, spending hours under the night sky studying stars, planets, nebulae, and galaxies through a pair of 10x50 binoculars, then moving on to the ubiquitous 2.4-inch department-store refractor, and ultimately a 6-inch reflector. I learned the constellations, made observing lists of lunar craters, asteroids, double stars, nebulae, and galaxies, and I never failed to know the whereabouts of the planets — evening or morning sky.

Through high school, nothing held me back — not the weight of the telescope and its heavy German equatorial mount; not the brilliant glare of a Mercury vapor streetlight in the alley that bordered our backyard; and not the trees

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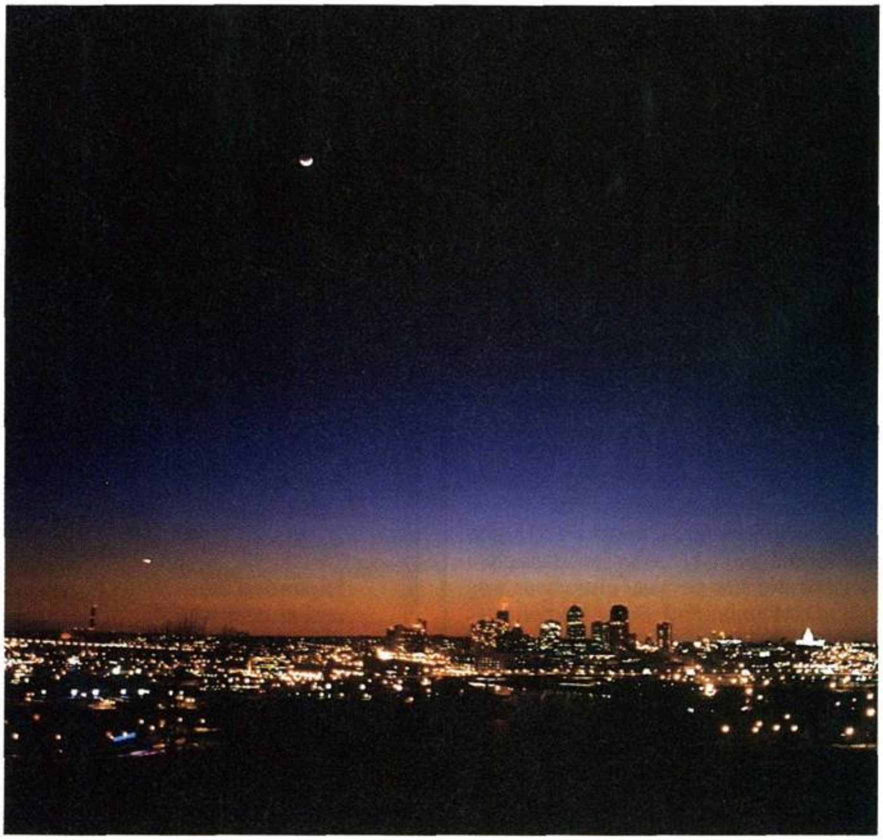

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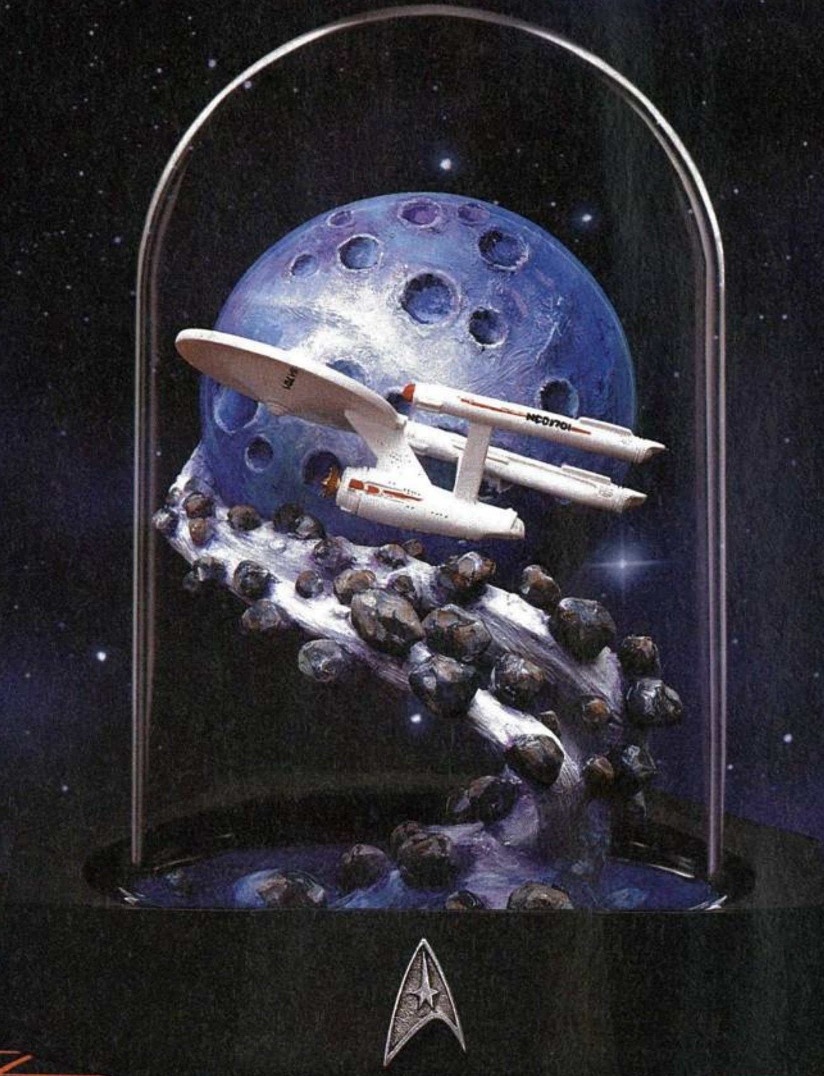

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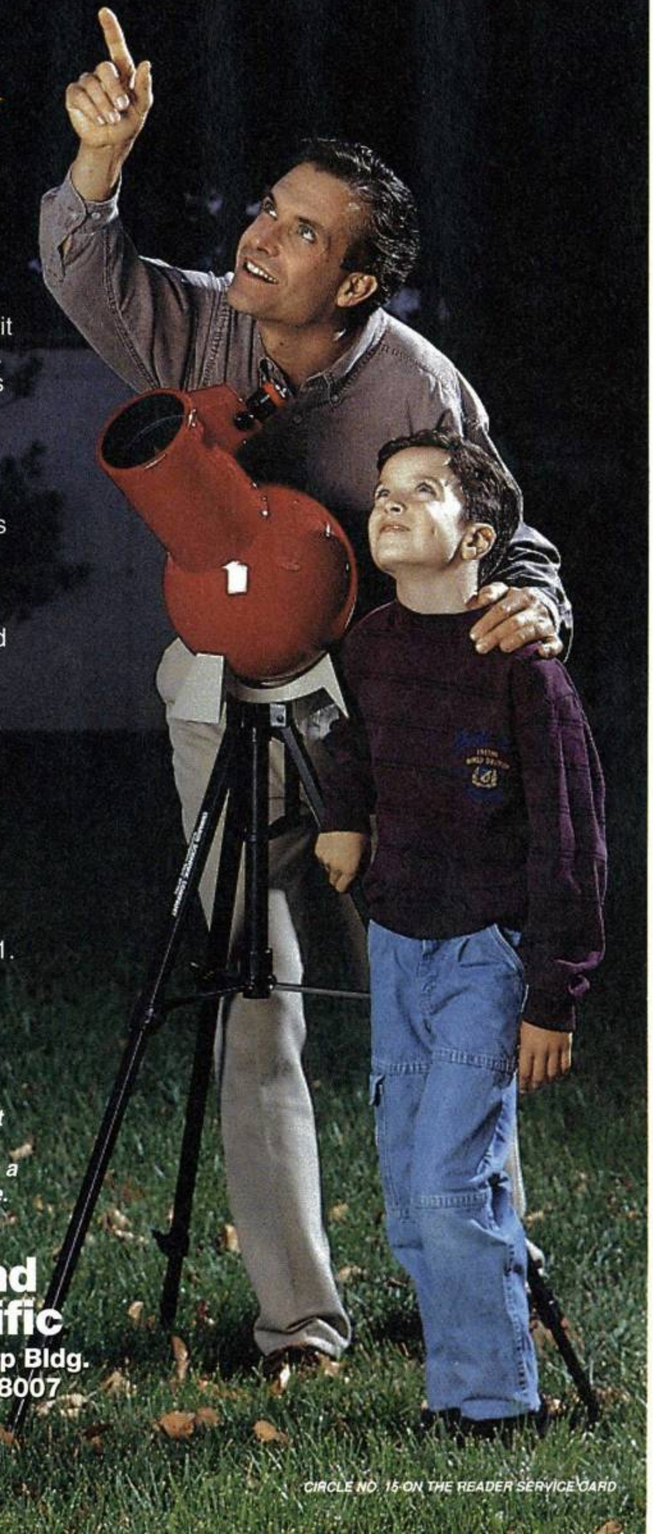

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that blocked large areas of the sky. The night sky was an Emerald City to me. Like Dorothy and her friends pressing on to the City of Oz, I persevered. On almost every clear night, you could find me in the backyard. My interest intensified through the years. Soon, just looking at the sky and the distant objects it held wasn't enough. I had to contribute, so I joined the American Association of Variable Star Observers and made hundreds of observations through my college years. In addition, I sketched planets, counted meteors, and did all the other things that allowed me to call myself a serious amateur astronomer.

Heck, after completing college, I even built an observatory on my father's farm. I had moved back home to work at the town's small weekly newspaper, and constructed an impressive roll-off roof affair with a concrete floor.

But slowly my post-college life began to change. Although I had never been overly concerned about money, now I had a student loan and car loan to pay without a lot of money to meet those obligations. Astronomy began to take the back seat more often. Into the front seat moved the demands of my job; in a small town, the duties of a newspaper editor don't end at 5 p.m. City council meetings and football games are nighttime matters that demand coverage.

When that job ran its course, I found another in Austin, home to more than 400,000 people and, not surprisingly, the source of a lot of Central Texas light pollution. From my mid-city apartment, the night sky I had come to know was nearly invisible. I didn't bother bringing my two telescopes to Austin. It didn't seem worth it, and there wasn't much space in the apartment anyway. So, recreational astronomy took another hit.

In my late 20s, I joined the rest of the indebted world by buying a house. It wasn't situated well for viewing the night sky, but it was what I could afford in the 80s. By then I had my telescopes, but taking them in and out of the house to see what little unobscured view of the heavens I had became a chore. It seemed like a good idea to keep the six-inch reflector outside, so I built a storage shed with a wide door for easy access under the trees out back.

Then my life really began to change. In the late 1980s I married and my wife and I decided that we needed a larger house. Goodbye, telescope storage! Lucky for me, my wife recognized and supported my astronomical interests by giving me the down payment for a 13.1-

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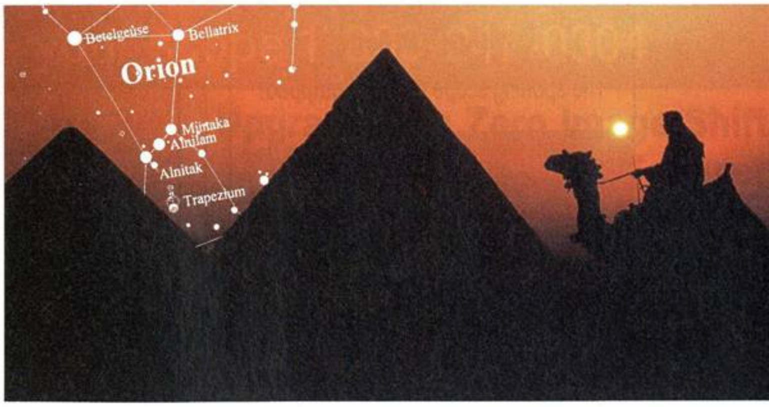

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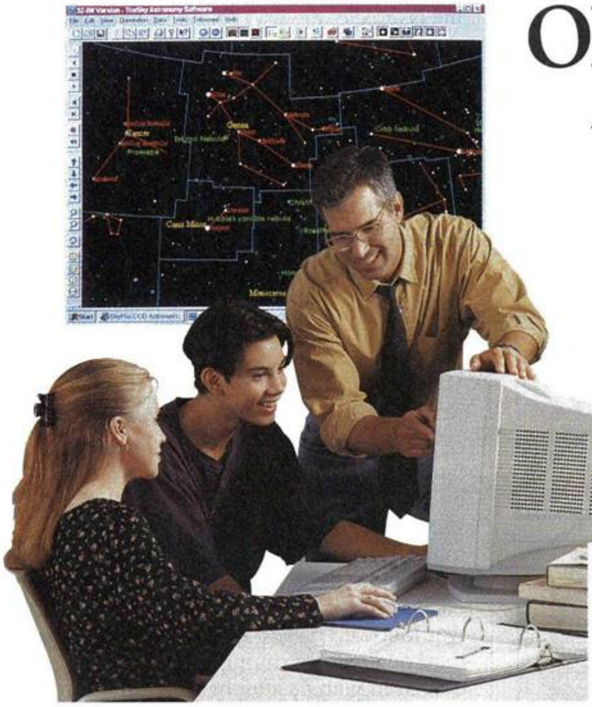

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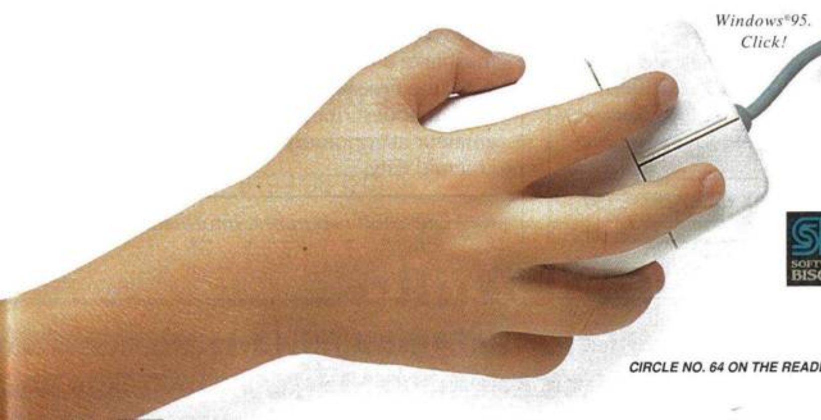

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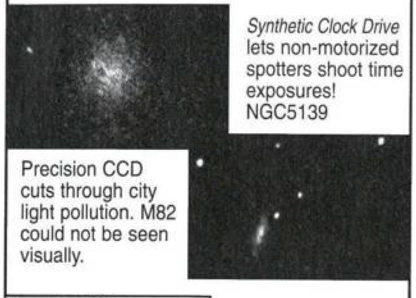
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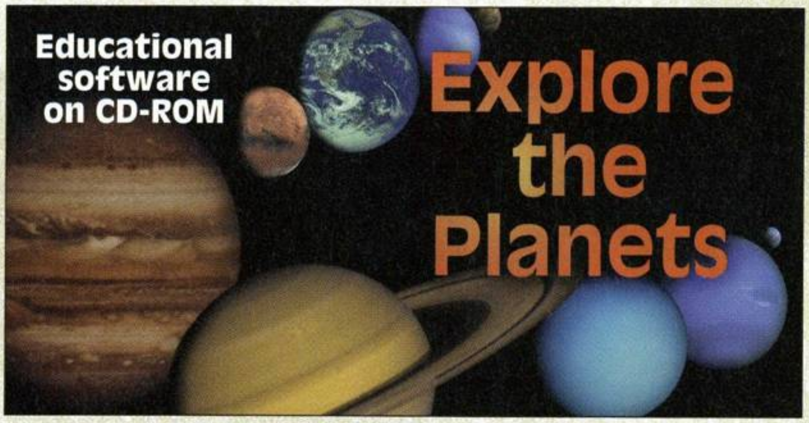

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inch Dobsonian on my birthday. A year later, it arrived. At first, I couldn't get enough observing. But though the scope was surprisingly portable for its size, moving it and its mount into and out of the house became a drag. Soon, I wasn't using it at all.

These days, it seems the pace of my life is accelerating. With the birth of my son nearly six years ago, and the growth of my stepdaughter to her teenage years, the demands and needs of the next generation take an increasing toll on time and finances. It's soccer practice and games for Nick, with a good measure of birthday parties, daycare picnics, and swimming lessons, and then Colorguard practice, football games, and innumerable other social activities for Shelly. Added to those tasks are trips to the doctor and dentist, house maintenance, and all the other things needed to manage a family.

In the past year or so, we've had other concerns as well. They began in late 1994, when my wife became aware her position as a court reporter with a state agency was on the block. That culminated with her layoff. Only a few days before then, my mother experienced her second heart attack, which was followed by bypass surgery and a third heart attack during recovery. She moved in with us after her release from the hospital.

In 1995, our household is in economy mode. Cutbacks are the rule as we reduce spending while my wife works to establish her freelance court reporting business. We've suspended magazine subscriptions — yes, even ASTRONOMY — plus cable channels, college savings, new car savings, savings for the sake of savings. And there won't be any vacations to speak of for awhile.

All in all, we haven't suffered a tremendous run of bad luck — no more than what many amateur astronomers face. When outside on a clear night, I still look up at the sky, recognize constellations, and sometimes catch the flash of a meteor or the steady motion of a satellite slipping between the stars. I persevere because, though astronomy must take a lower priority in my life for now, the fire still burns. It always will. I think that describes the attitude of most amateur astronomers who have seen the Emerald City. □

Ray Grasshoff is a public information officer for the Texas Higher Education Coordinating Board and a freelance writer living in Austin, Texas.

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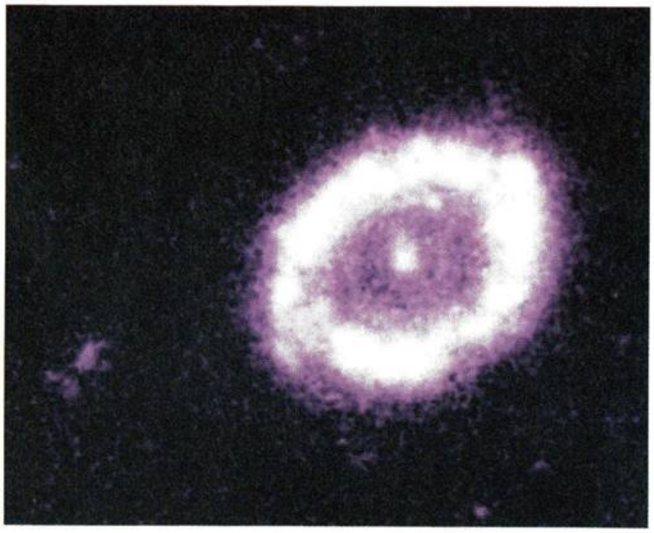
ASTRO NEWS

Astro-2 Mission Captures Surprises

The Astro-2 mission carried aloft by space shuttle Endeavor last March produced a flurry of preliminary results, many of which surprised astronomers. Three instruments studied deep-space objects in ultraviolet light. Images made with the Ultraviolet Imaging Telescope (UIT) depict a bright shell of hot, young stars around the center of galaxy M94 (below). A companion image in visible light shows no such concentration of stars (bottom). The shell marks the site of intense starburst activity during the last 10 million years.



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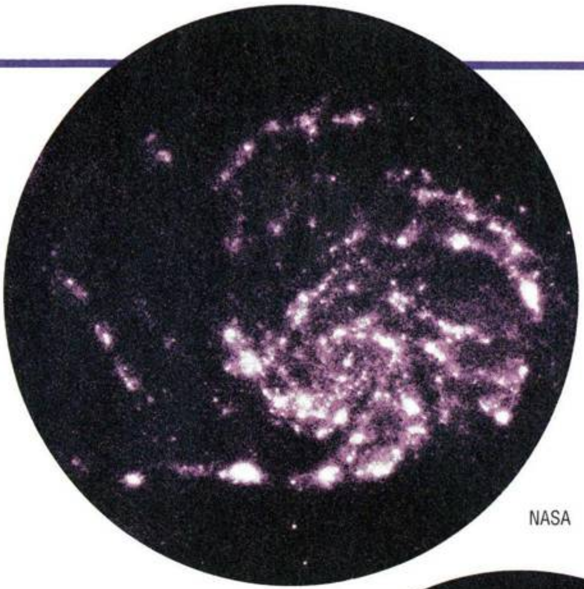
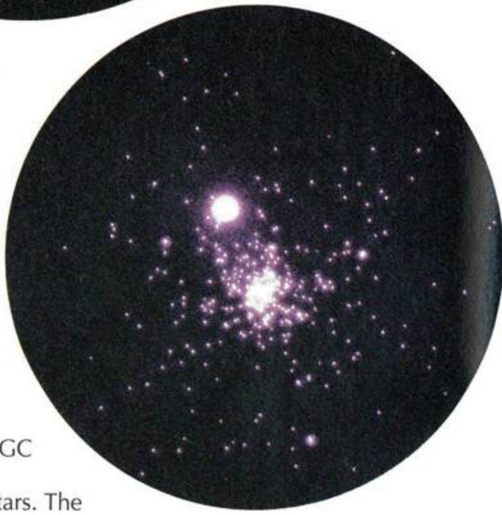


NASA

The UIT's portrait of the spiral galaxy M101 in Ursa Major (above, right) reveals sites of hot gas clouds glowing from the brilliant stars within them, scattered throughout the galaxy's arms. This image will permit astronomers to estimate the star forming rate of the galaxy and something about the types of newborn suns within it.

In globular star clusters like Pavo's NGC 6752 (right), the UIT imaged much older stars. The 355 stars in this picture are so-called horizontal branch stars near the end of their lives, and are glowing hotly, allowing them to be imaged in ultraviolet light. (The bright disk is a foreground star.) This first ultraviolet picture of NGC 6752, then, provides a census of the hot stars in this cluster, as the cooler stars do not show up.



Comet Hale-Bopp Shows Promise

Finally, there may be a bright comet in our future. If early trends continue, Comet Hale-Bopp should be visible to the naked eye for several months in late 1996 and early 1997, and may even rival the brighter stars.

Discovered independently on the night of July 22/23 by amateur astronomers Alan Hale in Cloudcroft, New Mexico, and Thomas Bopp near Stanfield, Arizona, the comet appeared as a diffuse, 11th-magnitude glow near the globular cluster M70 in Sagittarius. Once astronomers derived a preliminary orbit from early observations, they found Hale-Bopp lay over one billion kilometers from the Sun and wouldn't reach perihelion until 1997. To be so bright at such a great distance implied that the comet was experiencing an outburst, making predictions of its future brightness even more uncertain than it normally is with newly discovered comets.

What astronomers do know is that the comet will move slowly for the next several months, remaining in Sagittarius until next summer. It moves north fairly rapidly after that, and by the time it

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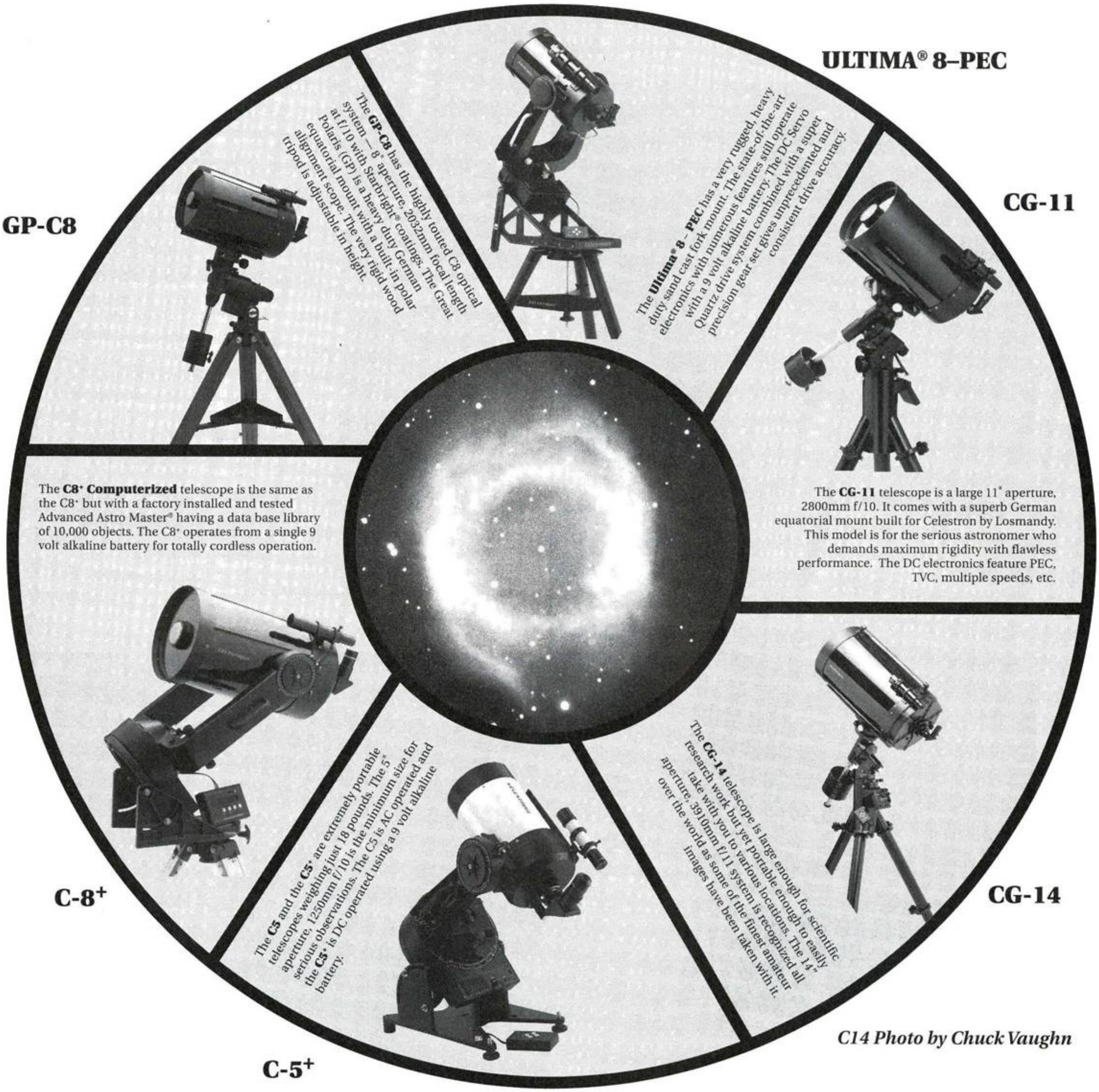

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C14 Photo by Chuck Vaughn

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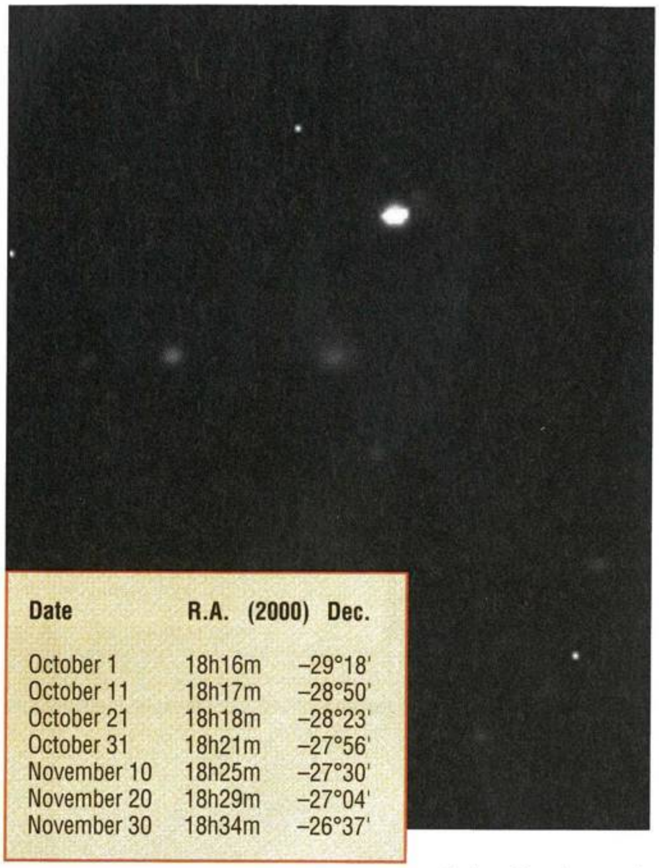


Warren Offutt

Date	R.A. (2000)	Dec.
October 1	18h16m	−29°18'
October 11	18h17m	−28°50'
October 21	18h18m	−28°23'
October 31	18h21m	−27°56'
November 10	18h25m	−27°30'
November 20	18h29m	−27°04'
November 30	18h34m	−26°37'

reaches perihelion in late March or early April of 1997, the comet should reside in Andromeda. The table above gives Hale-Bopp's positions during October and November. ASTRONOMY will provide detailed observing information on the comet once more up-to-date information becomes available.

A Mirage in Space

One of the brightest light sources in the sky turns out to be not so brilliant.

Astronomers thought FSC 10214 +4728 was a newly formed galaxy or perhaps a luminous quasar located some 10 billion light-years from Earth.

It was the most distant of the 300,000 objects observed by the Infrared Astronomical Satellite, implying that it must be extremely luminous and among the most energetic light sources known.

But Peter Eisenhardt and his team of colleagues at NASA's Jet Propulsion Lab in Pasadena, California, found that FSC 10214+4728 is really an illusion caused by a gravitational lens.

A nearby galaxy concentrates the light of what is probably an infrared-bright galaxy and magnifies it 100 times, creating the illusory bright source.

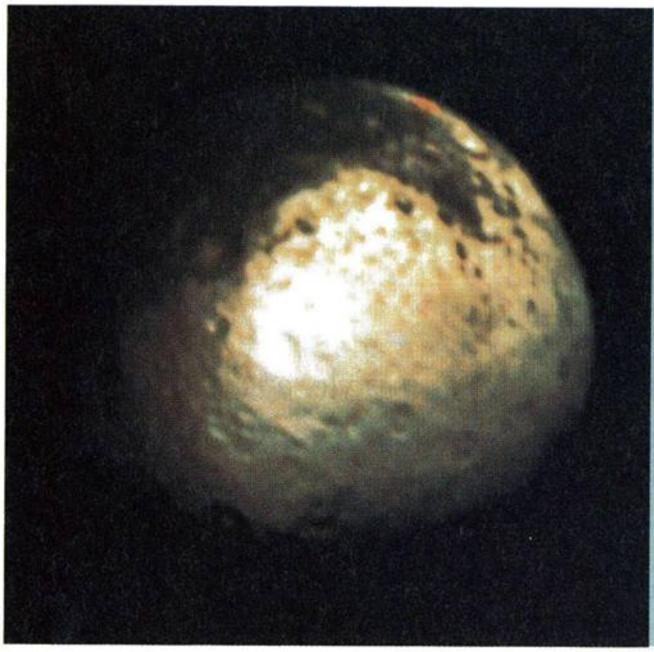
The astronomers uncovered the celestial deception using the Wide Field and Planetary Camera 2 aboard the Hubble Space Telescope.

Galileo Probe Released Successfully

Like an interplanetary paratrooper, Galileo's atmospheric probe is now free-falling toward Jupiter's cloudtops. Released from the main spacecraft on the evening of July 12 (eastern time), the rugged probe began a five-month journey that will end abruptly on December 7 when it slams into the gas giant's atmosphere at 106,000 miles per hour. It will then unfurl its main parachute and float down through the upper cloud layers, directly measuring for the first time Jupiter's chemical makeup, winds, clouds, and lightning.

New Saturnian Moons

Two Lowell Observatory astronomers using the Hubble Space Telescope have discovered at least two, and possibly as many as four,



NASA

Iapetus Gets a Facelift

Saturn's moon is a strange two-faced world. Its leading hemisphere is a dark reddish-black — reflecting a scanty 5 percent of the sunlight that strikes it. The trailing hemisphere's icy surface is bright, reflecting 50 percent of the light. Voyager images taken in visible light appeared to show a sharp boundary between the two hemispheres.

But in the June 1995 Icarus, Bonnie Buratti and Joel Mosher of the Jet Propulsion Laboratory report that previously overlooked Voyager images taken in near-ultraviolet light show a gradual change between the light and dark regions. Moreover, when Buratti and Mosher scrutinized the visible light data in more detail, they noticed a gradual change in color. These new findings virtually prove the theory that Iapetus's leading hemisphere leisurely sweeps up dark silicate- and carbon-rich dust that meteorites knock from Saturn's outermost moon Phoebe. Previously, some astronomers thought internal geological forces were responsible for Iapetus' two-faced nature.

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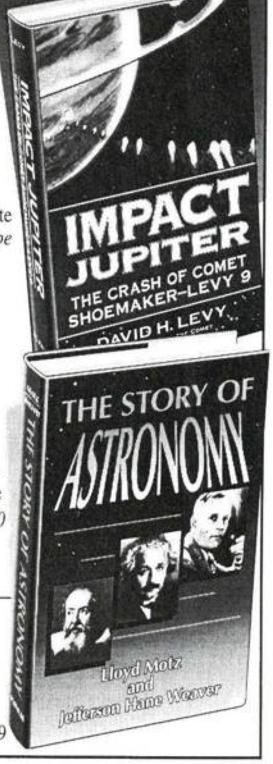
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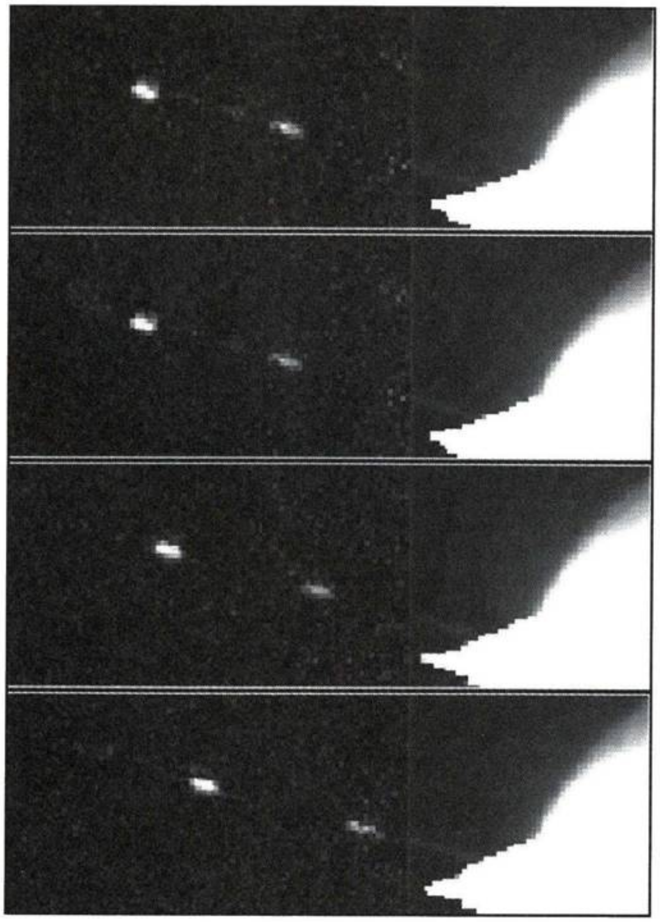
new moons orbiting the ringed planet Saturn. The discovery was made as the telescope imaged Saturn on May 22, 1995, when the planet's rings were tilted edge-on to Earth, a phenomenon that happens only about every 15 years.

"We were trying to determine the thickness of the rings and the precession of Saturn's pole," Lowell Amanda Bosh told ASTRONOMY. "We were always aware of the possibility of finding new satellites. We were surprised when we saw movement where none was predicted."

Each measuring less than 45 miles across, two of the moons have orbits similar to those of a pair of moons discovered by Voyager 1 in 1980. Subsequently named Atlas and Prometheus, these two satellites are calculated to be at different locations than the new sightings. "If these two satellites are the same as those seen by Voyager, then their orbital longitudes are different from what we expected," Bosh said. Further study should resolve the identity when Saturn goes through the second of three ring plane crossings on August 10.

Bosh and her co-researcher, Andrew Rivkin, say that the two other new moons lie outside Saturn's thin F ring. One orbits just outside the ring, and the other about 3,700 miles outside the F ring. From 1655 to 1980, 13 Saturnian moons were discovered — all during ring-plane crossings. "These moons may be as small as 10 miles across," says Bosh. "It's pretty amazing to find something that small from 925 million miles away." If all four satellites are new, the discoveries bring the total number of Saturnian moons to 22. — *Michael Carroll*



Amanda S. Bosh, Andrew S. Rivkin, NASA

A NEW MOON OF SATURN appears as an elongated dot near the center of these images made with Hubble made over 30 minutes on May 22, 1995. Saturn is the bright blob at right.

Astro-2 Weighs In With Helium

This past spring's shuttle-borne Astro-2 observatory has gathered further proof that the Big Bang spawned helium. During its flight last March, the Hopkins Ultraviolet Telescope (HUT) built by Johns Hopkins University detected traces of the element by scrutinizing the ultraviolet light of a distant quasar.

An intervening cloud of primordial helium, thought to be left over from the Big Bang itself, absorbed some ultraviolet light from the quasar and betrayed itself as dark absorption lines in the distant object's spectra.

The finding bolsters last year's observations made by the Hubble Space Telescope of a completely different quasar that also showed helium absorption features in its ultraviolet spectrum.

However, the Astro-2 data is of higher quality and allows astronomers for the first time to estimate the abundance of helium and hydrogen in the very young universe. Calculations that use the data are in line with predictions made by theorists, a crucial victory for the standard big bang theory.

The HUT data also helps scientists deduce the elusive nature of dark matter. So far, the observable universe only adds up to ten percent of the amount needed to produce many gravitational effects observed in the cosmos. The big bang theory predicts that about ten percent of the yet-to-be-discovered mass should be normal material, the stuff of which everything from people to planets are made, rather than more exotic forms of matter. The estimated abundance of primordial helium and hydrogen (both of which are normal matter) based on HUT's data shows that this hunch is correct.

Seeing Close to a Black Hole

Astronomers using the Japanese X-ray satellite ASCA have just found a way to peer down into the region just outside a supermassive black hole. In July 1994, ASCA observed the telltale signature of material spiraling into a black hole weighing 10 million Suns located in the bright core of the galaxy MGC-6-30-15. ASCA detected a distorted spectral line from ionized iron in the whirling disk of gas that surrounds the black hole. The distortion perfectly matches the pattern scientists expect for material about to plunge into a black hole.

The ionized iron becomes visible in the hot, innermost part of the disk very close to the black hole. According to Einstein's theory of relativity, the black hole's immense gravity causes strange effects in this region of space. Gravity stretches light rays trying to escape the black hole's grasp and it slows time to a crawl. ASCA observed these effects. The iron spectral line was stretched out over a broad range of frequencies, and these frequencies were reduced, a result of the slowdown in time.

"The fact that they're

(continued on page 32)

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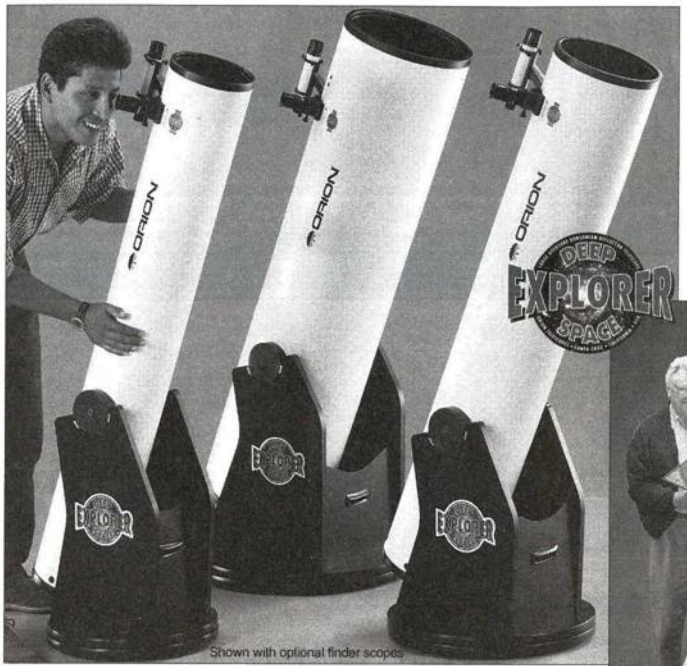

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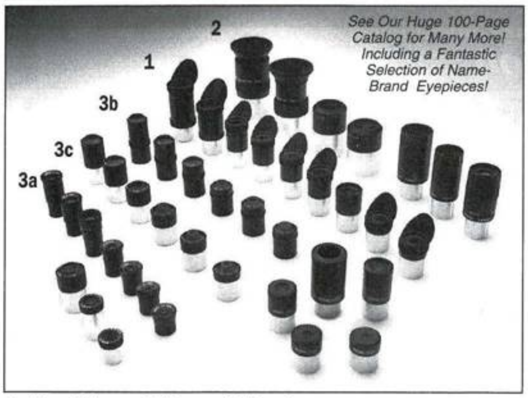

See Our Huge 100-Page Catalog for Many More! Including a Fantastic Selection of Name-Brand Eyepieces!

1. Orion 5-Element Ultrascopic™ Eyepieces

With Superb, High-Performance Ultra™ Multi-Coatings!

Made for Orion by Japan's finest lens maker, Ultrascopic eyepieces yield the highest contrast, greatest light transmission and best overall image fidelity obtainable. With a superior 5-element design and Ultra™ Multi-Coatings on every surface, they achieve a level of performance "name brand" 4-element models can't match. Wide 52° flat field of view. Removable contoured rubber eyeguard. The 5mm and 3.8mm feature advanced 7-element designs which yield surprisingly long eye relief. Absolutely guaranteed to knock your socks off!

Medium-High Power 5-element

20mm #8566, 15mm #8568, 10mm #8570, 7.5mm #8572 ***$95.00 ea.*** (3.45)

Wide Field 5-element	
25mm #8564	***$109*** (3.45)
30mm #8562	***$129*** (3.45)
35mm #8560	***$149*** (3.45)
High Power 7-element -Long Eye Relief	
5mm #8574	***$119*** (3.45)
3.8mm #8576	***$109*** (3.45)

2. UltraZoom™ 7-21mm

The finest zoom you can buy for your 1.25" telescope. For astronomy or terrestrial observing. 65°-35° field. Fully coated.

#8556 ***$189*** (3.67)

✧ ***Sirius™***

Plössl 1.25" Eyepieces

Fantastic Name-Brand Quality Eyepieces at an Incredible Low Price!

2 New Sizes – 12.5mm & 32mm

You could pay nearly twice the price for "famous name" Plössl eyepieces, but we don't think you'll be able to tell the difference if you compare them to these fantastic eyepieces! Sirius Plössls are top-quality, 50° apparent field (43° 40mm) eyepieces with extremely sharp images of impressively high contrast. Ideal for all types of telescopes. The Classic 4-element Plössl design is renowned for its fantastic performance and has become the standard to which all other eyepieces are compared. The all-Magnesium fluoride fully-coated optics are mounted in precision black anodized aluminum housings with chrome-plated brass 1.25" barrels for durability and precision fit.

7.5mm #8738, 10mm #8736, 12.5mm, #8726, 17mm #8734, 26mm #8732.
Each ***$59.95*** (3.45)
32mm #8728, 40mm #8730
Each ***$79.95*** (3.67)
Custom Field Case #5911 ***$12.95*** (2.19)
(Holds up to 4 eyepieces except for the 40mm)

SPECIAL OFFER – Buy Two or More and Save!

- **Any 2** **$10 off (Save $5 ea.)**
- **Any 3** **$30 off (Save $10 ea.)**
- **Any 4** **$60 off (Save $15 ea.)**
- **Any 5** **$85 off (Save $17 ea.)**
- **Any 6** **$114 off (Save $19 ea.)**
- **ALL 7** **$140 off (Save $20 ea.)**

3. Orion Explorer™ Multi-Coated 1.25" & .965" Eyepieces

These fine quality multi-coated eyepieces offer great performance at Orion''s low direct-discount price. Black anodized, internally blackened, threaded for filters (except 40mm .965").

b 1.25" Orthoscopic
5mm #8500, 7mm #8502, 9mm #8504, 12.5mm #8506, 18mm #8524, 25mm #8526
$59.95 each (2.98)

c 1.25" Kellner
6mm #8536, 9mm #8538, 12mm #8540, 18mm #8508, 25mm #8510, 40mm #8512
$49.95 each (2.98)

a .965 Orthoscopic
5mm #8580, 7mm #8581, 9mm #8582, 12.5mm #8583
$54.95 each (2.98)

a .965 Kellner & Achromatic Huygenian
K 18mm #8584, K 25mm #8585, AH 40mm #8586
$39.95 each (2.98)

Illuminated Reticle Eyepieces

12.5mm Plössl Illuminated Reticle 1.25"
Illuminator has fully adjustable brightness. Features double crossline reticle. Batteries included.
#8484 ***$129*** (3.45)

9mm Orthoscopic Illuminated Reticle 1.25"
Adjustable brightness illuminator. "Bull's-eye within crosshairs" reticle. Needs 2 SR-44 batteries, not included.
#8488 ***$149*** (3.67)

12mm Kellner Illuminated Reticle 1.25"
Features double crossline reticle and red LED illuminator. Plugs into power panel drive bases.
#8482 ***$79.95*** (3.45)

12mm Kellner Illuminated Reticle 1.25"
Same as #8482 above except has a wireless illuminator. Needs 2 SR-44 batteries, not included.
#8481 ***$99.00*** (3.45)

Shorty™ Barlows

The short bodies allow extra versatility: provides 2x magnification when the eyepiece is inserted directly and 3x magnification when positioned before the diagonal on a refractor or SC. These will work in all telescopes, including those where longer barlows won't work.

.965" #8710 ***$49.95*** (2.98)
1.25" #8711 ***$59.95*** (3.45)

Barlow Lenses

Orion offers a large selection of barlow lenses, allowing you to double or even triple the power of your eyepieces, maximizing the versatility of your collection. Available in .965", 1.25" and 2" diameters.

Fully Baffled 2x Barlow
Multi-coated, with internal baffling to block transmission of stray light. Premium performance at a remarkable price.

.965"	#8740	***$44.95*** (2.98)
1.25"	#8746	***$49.95*** (2.98)
2"	#8724	***$94.50*** (3.95)

VariPower 2-3x Barlow
Allows you to adjust the magnification factor of the barlow by sliding the internal cell along a calibrated scale. Fully multi-coated optics. 1.25" barrel.
#8748 ***$64.95*** (3.45)

Filters

SkyGlow™ Light Pollution Filters

The finest available. SkyGlow™ filters from Orion make detailed deep-sky observing possible from light-polluted city and suburban locations. Sophisticated multi-layer technology actually absorbs light pollution! Greater blocking and higher transmission than competitive models. See catalog for details.

SkyGlow UltraBlock Filters

(Visual Only)
For severely light-polluted areas and faint nebulae.
.965" UltraBlock Filter fits .965" eyepieces.
#5655 ***$79.95*** (2.98)
1.25" UltraBlock Filter fits 1.25" eyepieces.
#5654 ***$99.95*** (3.45)
2" UltraBlock Filter fits 2" eyepieces. #5657
SC UltraBlock Filter fits rear cell of Meade & Celestron SC scopes. #5656 ***$149 ea.*** (3.67)

Glass Solar Filters

High-quality optical glass filters, for superb images of the sun with your telescope. Triple-coated with advanced scratch-resistant stainless steel alloy. Great for both visual and photographic use. Slide fits over the front of your telescope.
For 8" SCs #7713 ***$144*** (4.05)
For 10" SCs #7715 ***$162*** (4.05)
NEW! Solar glass filters for Deep Space Explorer reflectors. Many other sizes available. See our free catalog for details.

SkyGlow™ Broadband Filters

(Photographic & Visual)
For slightly to moderately light-polluted areas.
1.25" Broadband Filter fits 1.25" eyepieces.
#5660 ***$79.95*** (3.45)
SC Broadband Filter fits rear cell of Meade & Celestron SC scopes. #5658 ***$99.95*** (3.45)
52mm Broadband Filter For 52mm camera lenses. (Adapter rings available for other diameters.)
#5668 ***$87.50*** (3.45)
2" Broadband Filter fits 2" eyepieces.
#5659 ***$119*** (3.45)
.965" Broadband Filter fits .965" eyepieces.
#5661 ***$49.95*** (2.98)

Moon Filters

Cuts 87% of the light from the Moon. Reduces glare by uniformly reducing light transmitted over the entire spectrum.
.965" #5664, 1.25" #5662 ***$15.95*** (2.43)

Color Eyepiece Filters

Made from absolutely the highest quality photographic-grade precision-ground optical glass, anti-reflection coated. Ideal for contrast-enhancing planetary and lunar observations and photography with any telescope. The black anodized, machined aluminum cells thread into any standard eyepieces, or into our universal camera adapters.

.965" Set of 4 #80A Blue, #58 Green, #25 Red, #15 Yellow. #5510 ***$49.95*** (2.98)
1.25" Basic Set of 4 #80A Blue, #58 Green, #25 Red, #15 Yellow. #5514
1.25" Expansion Set of 4 #21 Orange, #47 Violet, #11 Yellow-Green, #82A Blue. #5516
1.25" Advanced Set of 4 #8 Yellow, #23A Red, #38A Blue, #56 Green. #5570
$59.95 ea. (2.98)
2" Set of 4 Includes #80A Blue, #58 Green, #21 Orange and #12 Yellow.
#5513 ***$99.95*** (2.98)
Individual Filters
.965" & 1.25" ***$14.95***, 2" from ***$32.50***

Observing Aids

Eyepiece & Accessory Cases

With patented unbreakable latches, die-cut foam inserts. (Inside Dimensions shown)

Small Case (shown)
11"x7"x3"
#5951 ***$17.95*** (2.78)
Medium Case
12.5"x9"x5"
#5952 ***$26.95*** (3.36)
Large Case
16"x11"x5"
#5953 ***$49.95*** (5.19)

Orion® FlexiShield™ Dew Caps

Forms into a tube with Velcro closure, opens flat for storage and travel. Models to fit most telescopes.
8" Celestron/Meade SC #4200 ***$44.95*** (2.98)
Other sizes available for scopes 3.5" to 14". See our catalog for details.

Orion® Dew Zapper

Gently replaces lost heat, a sure-fire cure for dew problems.
8" Dew Zappers-fit all Meade & Celestron 8" SCs
DC #3503, AC #3504 ***$47.95*** (2.98)
10" Dew Zappers-fit all Meade 10" SCs
DC #3506, AC #3508 ***$54.95*** (2.98)
11" Dew Zappers-fit all Celestron 11" SCs
DC #3510, AC #3512 ***$59.95*** (2.98)

Night Vision Flashlights

An essential accessory for astronomers. Many more in our catalog.

Nitewriter Pen	#5709	***$9.95*** (1.79)
Hands-Free Flex Light	#5707	***$19.95*** (2.43)
Starlite LED Flashlight	#5714	***$24.95*** (2.43)
Celestron LED Light	#5720	***$21.95*** (2.43)

Observer's Chairs

Standard Model-Adjustable height center column and padded seat.
#5935 ***$34.95*** (4.70)
Deluxe Model-Built for professional musicians. Extra heavy duty.
#5934 ***$94.50*** (8.02)

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(800) 447-1001

Telescope Covers and Tote Bags

Soft SC Case

These padded carrying cases are a space-saver when you are packing your scope for a long trip, and don't have room for the regular bulky case. Constructed from the finest materials, heavily stitched, nylon lined, reinforced bottom. Sides have 1 1/2" of foam padding.

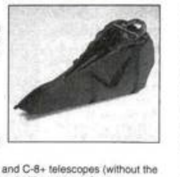
For Celestron & Meade 8" (except LX200)	#15141	***$139*** (4.98)
For Meade 8" LX200	#15144	***$149*** (4.98)
For Celestron C-5 & Meade 2045D	#15142	***$109*** (4.45)

Dobsonian Tote Bags

Fits Orion Deep Space Explorer tubes. May also fit some home-built Dobsonians. Made of blue waterproof nylon fabric with double-stitched seams. Handy nylon drawstring closure with positive catch. Black nylon shoulder straps.

6" DSE Bag	10"x10"x60"	#15150	***$49.95*** (3.41)
8" DSE Bag	12"x12"x62"	#15151	***$54.95*** (3.41)
10" DSE Bag	14"x14"x68"	#15152	***$64.95*** (3.54)
12.5" DSE Bag	17"x17"x74"	#15153	***$84.95*** (3.54)

Tripod & Wedge Bags



Designed to hold Schmidt-Cassegrain tripods and wedges. Made of 100% Cordura nylon, so your bag won't tear, rip or mildew. Sturdily constructed, with carrying straps.

Economy Tote and Storage Bag
Inexpensive reinforced tote bag without padding. Zippered pocket, handy nylon drawstring cord with a positive catch. Length, 4' 2", width 1' 5".
#15095 ***$34.95*** (3.41)

Lightweight Tripod Bag
Fits the Celestron lightweight tripod for C-5 and C-8+ telescopes (without the wedge). Zippered closure. Inside pocket. Lined with waterproof nylon.
#15143 ***$43.95*** (3.26)

Field Tripod & Wedge Bag
For Celestron or Meade standard tripods and wedge combinations (not Meade Superwedge or Celestron Ultima wedge). Allows storage of the wedge without changing polar alignment, or removing the wedge from the tripod. Zippered closure. Length 4' 2", width 1' 10", circumference 3' 6".
#15096 ***$79.95*** (5.19)

Deluxe Tripod & Wedge Bag
Fits Ultima tripod and wedge. Allows wedge/tripod combination to be stored without removing the wedge or disturbing the wedge tilt adjustment. Lined with waterproof nylon. The bottom is neoprene for durability. Heavy-duty zipper closure.
#15140 ***$109*** (4.45)

Scope Saver™ Telescope Covers

Ideal for covering your scope after set-up, but before it's dark enough to observe. Also perfect if you keep your scope set up at home or an observatory. Made of blue waterproof nylon fabric with double-stitched seams. Nylon drawstring closure with cord lock.

For Dobsonian Telescopes
Covers entire tube and base. Great for keeping it covered while not in use or while transporting it in the trunk of your car. Fits Dobsonian, Newtonian tube assemblies, or home-built telescopes.

6" Model	9"x12"x54"	#15135	***$34.95*** (2.43)
8" Model	10"x14"x54"	#15136	***$39.95*** (2.43)
10" Model	12"x14"x62"	#15137	***$50.95*** (2.43)
12.5" Model	14"x16"x68"	#15138	***$59.95*** (2.43)

For SCs and Small Equatorial Telescopes
Fits over the optical tube either while attached to a tripod or before putting into a case.

8" SC Model 10"x12"x34" Fits any Celestron or Meade 8" Schmidt-Cassegrain telescope. #15130
$33.95 (2.43)
10"-11" SC Model 14"x16"x44" Fits Meade 10", Celestron Ultima 11" telescopes (not original C-11) and Celestron CG-11. #15131
$39.95 (2.43)
4.5"-6" Model 6"x22"x38" Fits 4.5" to 6" Newtonian reflectors, such as Space Probe 4.5, Celestron 4.5, C6.
#15134 ***$37.95*** (2.43)

NOW! Orion products are available at selected local authorized dealers across the country. Call us to find the store nearest you: (800) 447-1001.

Visit One of Our Three Unique Retail Stores

America's biggest & best selection of telescopes, binoculars & accessories. Three convenient Northern California locations!

Some prices in retail stores may vary.

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3609 Buchanan St., at Bay • **415-931-9966**
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From Hwy 280 take Cupertino exit, from Hwy 85 take Saratoga-Sunnyvale Rd. or Stevens Creek exit
From Los Gatos take Hwy 9 to Saratoga-Sunnyvale Rd.
MONTEREY BAY-SANTA CRUZ
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CIRCLE NO. 4 ON THE READER SERVICE CARD

Binoculars

Orion® 50mm Vista™

Superb for long distance nature observation and astronomy. The image quality will amaze you even when compared to much higher priced binoculars. Fully multi-coated optics provide high-fidelity true color images without ghosting or other aberrations. Long 16mm eye relief and roll-back eyecups for eyeglass wearers. BAK-4 prisms. Weighs just 28 oz. Includes deluxe hard carrying case, rain shield, lens caps, and straps.

7x50	6.0° field of view #9355	***$219*** (5.19)
10x50	5.3° field of view #9353	***$219*** (5.19)

50mm Explorer™ Binoculars

High performance, large diameter binoculars with BAK-4 prisms and multi-coatings. Great for both astronomy and daytime observation. Comfortable ergonomic body design.

7x50	#9306	***$129*** (4.44)
10x50	#9308	***$134*** (4.44)

Orion® 50mm UltraView™

The perfect binocular for eye- and sunglass wearers. Extra-long 23mm eye relief and unique rubber pop down eyepiece guard allows viewing with or without eyeglasses. Fully multi-coated optics. BAK-4 prisms. Wide 6.5° field of view. Close focus 16'. Weighs 32 oz.

10x50	#9351	***$169*** (4.95)
7x50	#9357	***$179*** (4.95)

7x50 Adlerblick Binoculars

Incredible wide-field eyepiece design. Fully multi-coated. BAK-4 prisms make the 7x50 Adlerblick rival European brands selling for many times the price. 7° field of view, eye relief 26mm, exit pupil 7.14mm. Soft roll-down rubber eyeguards. Weighs 28 oz.

#9612 ***$349*** (5.28)

Observer™ Super Compacts

So tiny and lightweight, you'll take them everywhere! Great for general observation, stadium sports, nature hikes and travel. Ultra-small roof prism design with fully coated optics. Slip-resistant black rubber armoring, fold-down rubber eyecups, soft nylon case & neck strap.

8x21 offers good brightness, a 7.1° field of view & weighs only 6 oz! #9460 ***$57.95*** (3.95)

10x25 is great for longer distance viewing; just a bit longer and only 7 oz., it still fits easily in shirt pocket or purse. #9465 ***$59.95*** (3.95)

80mm FMC Giant Binoculars

20% more light transmission than "fully coated"-Fully Multi-Coated optics and superior BAK-4 prisms provide fantastic contrast and greatly improved edge sharpness.

11x80 MC Brightest, widest field available. Ideal for deep-space observation under dark skies. Hand-holdable. #9502

16x80 MC 45% higher power, excellent for astronomy & daytime observation. Tripod recommended. #9496

20x80 MC Highest power model perfect for smaller deep-space objects and long range daytime views. Tripod required. #9498

$469 (8.05)

Orion® 70mm FMC Giants

The standard for hand-holdable astronomy binoculars. Fully multi-coated. Weighs only 58 oz., yet the same brightness and 7mm exit pupil as our 11x80 MC model. Superior 'BCF' body design. Includes tripod mounting adapter.

10x70 #9501, **14x70** #9494 ***$369*** (6.97)

SuperGiant™ 100mm Binos

Gigantic, almost 4" lenses gather 156% of the light of 80mm binoculars. 14x has individual eyepiece focus, 25x has center focus, fully multi-coated optics and BAK-4 prisms. Tripod mounting plate, metal-clad case. Weight 7.5 lbs., height 13.5".

14x100 #9495, **25x100** #9497

$1299 (14.00)

Quality Components

Parabolic Primary Mirrors

Excellent hand-figured parabolic mirrors guaranteed to meet theoretical limits of resolution. Fine polished, coated twice: with Aluminum and Silicon monoxide. Very competitively priced!

Call for pricing

Standard Primary Mirrors
Made from fine soda-lime plate glass, 1:8 thickness ratio. Guaranteed 1/8 wave. Sizes: 6" f/8, 8" f/6, 10" f/5.6, 12.5" f/4.8.

Pyrex Low Expansion Mirrors
Made from fine annealed Pyrex brand low expansion glass, 1:8 thickness ratio. Guaranteed 1/10 wave. Available with standard or 94% reflectivity Enhanced Aluminum coatings. Sizes: 6" f/5, 6" f/8, 8" f/6, 10" f/4.5, 10" f/6, 12.5" f/6.

Elliptical Secondary Mirrors

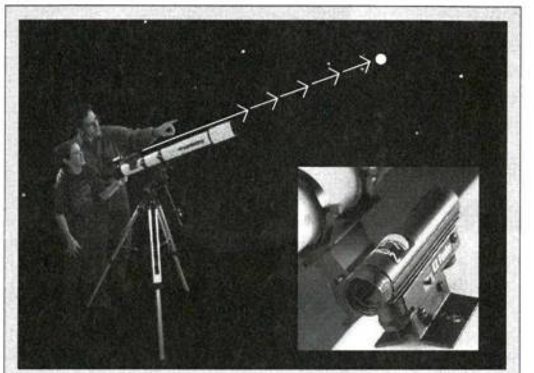
Made from fine annealed Pyrex brand glass, aluminized and SiO overcoated. Guaranteed 1/10 wave accuracy. Available with standard or high reflectivity Enhanced Aluminum coatings. Nine sizes from 1.00 to 4.00" minor axis.

Call for pricing

Astrositall Zero Expansion Mirrors

Astrositall is a glass-ceramic material with an ultra-low coefficient of thermal expansion, similar to Zerodur. Ideal for harsh environmental conditions. 1:7 thickness ratio. Guaranteed ±1/10 wave surface accuracy. Enhanced Aluminum coatings. 6" f/8, 6" f/5, 8" f/6, 10",f/6
Astrositall Elliptical Flat Mirrors 1.30", 1.52", 1.83", 2.14"

Call for pricing



EZ Finder™ Reflex Sight

This fantastic device makes pointing a telescope almost as easy as pointing your finger. Keep both eyes open and look through EZ Finder, and you'll see the image of a red dot projected at infinity, showing exactly where the telescope is aimed in the sky.

Installs on any telescope in minutes. Wide 10° field of view, low and high brightness settings. Fits Meade & Celestron SC scopes in existing mounting holes; attaches easily to other scopes.

#7075 ***$49.95*** (3.45)

6x30 Achromatic Finder Scopes

6x30mm-Same unit used on $1000+ "big name" telescopes. With 2-ring metal bracket, fits scopes 6"-12".
#13023 (white)
$49.95 (3.41)

6x30mm Right Angle-90° prism for right-angle viewing. Includes bracket.
#13021 (white) ***$79.95*** (3.41)

Large Aperture Finder Scopes

These are higher-quality finders at very reasonable prices! Fully coated wide field achromatic optics with adjustable focus. Precision crosshairs. White or black enameled metal tube. (Mounts sold separately.)

8x50mm 2.7x light grasp of 30mm models. Bright 6.25mm exit pupil. #7090 (white) #7094 (black) ***$79.95*** (3.41)

8x50mm Illuminated Wireless illuminator with adjustable brightness. #7092 (white) #7096 (black) ***$119*** (3.41)

9x60mm 44% more light grasp than 50mm models. #7091 (white) #7095 (black) ***$119*** (3.41)

9x60mm Illuminated Wireless illuminator with adjustable brightness.
#7093 (white) #7097 (black) ***$159*** (3.41)

Low-Profile Helical Focusers

Economical yet precise focusing. Ideal for fast optical systems. Cast aluminum base with threaded machined aluminum inner tube.

1.25"	#13014	***$39.95*** (2.45)
2.0"	#13016	***$59.95*** (2.98)

Rack-and-Pinion Focusers

Finest in their class! Diagonal-cut plated brass racks, oversized knurled knobs, long focus travel.

1.25"
#13007
$69.95 (2.98)

2.0"
includes 1.25" adapter.
#13003 ***$119*** (3.95)

Superb Dovetail Aluminum Mounts for 50mm and 60mm Finder Scopes

Instantly install or remove your finder, without tools, without disturbing alignment! Black anodized, fits any scope 6" and over including Celestron & Meade SCs.

8x50mm bracket	#5040	***$39.95*** (2.45)
9x60mm bracket	#5041	***$47.95*** (2.98)
Extra mounting plate	#5050	***$14.95*** (2.19)

Orion Accessories

Call Toll-Free for Our 100 Page Color Catalog and See Even More!

Orion Accessories are absolutely guaranteed to be the finest quality available. Compare them side-by-side with "famous name" products! We buy direct from many of the same sources, always specify the highest quality, & pass along the savings to you! 100% satisfaction guaranteed!

Universal Camera Adapters

For prime focus or eyepiece projection astrophotography.

.965"	#5268	***$27.95*** (2.98)
1.25"	#5264	***$29.95*** (2.98)
Hybrid 1.25"/.965"	#8782	***$29.95*** (2.98)

Variable Power Camera Adapter

Allows variable projection distances during eyepiece projection photography. For 1.25" eyepiece holders.
#5262 ***$39.95*** (2.98)

Tele-Extenders for SC Scopes

For high powered photography with your Meade, Celestron 4", 8", 10", 11", 14" Schmidt-Cassegrain.

Standard Tele-Extender	#5125	***$29.95*** (2.98)
Variable Tele-Extender	#5127	***$39.95*** (2.98)

T-Adapters for SC and MAK

Threads to rear cell of telescope, requires t-ring for your camera model.

for SC	#5116	***$26.95*** (2.98)
for C-90	#7115	***$34.95*** (2.98)

T-Rings for all 35mm Cameras

Available for many different camera types; call toll-free or see our catalog for your particular model.

Orion Slow Motion Adapter

Attaches to your photo tripod pan head. 2 slow motion control knobs to make precision adjustments in altitude and altazimuth. Very handy for tracking planets, the Moon, etc. with refractor telescopes and small spotting scopes. Attaches with a standard 1/4-20 thread.

#7033 ***$36.50*** (2.19)

45° Erect Image Diagonal Prisms

Ideal for all refractors and compound telescopes used for terrestrial viewing.
Hybrid 1.25"/.965" Diagonal #8792
1.25" Diagonal #8790
.965" Diagonal #8791 ***$44.95*** (3.45)

90° Star Diagonal Prisms

Orion's multi-coated diagonals are ideal for refractors and Schmidt-Cassegrains.

1.25" Star Diagonal	#8763	***$49.95*** (2.98)
.965" Star Diagonal	#8761	***$29.95*** (2.98)
Hybrid 1.25"/.965"	#14008	***$33.95*** (2.98)

Orion Ultra™ 2" Diagonals

2" Prism Diagonal – Absolutely the finest quality multi-coated 2" prism for highest light transmission.
For refractors #8770
For Schmidt-Cass. #8771 ***$219*** (4.71)

2" Mirror Diagonal – Affordable, high-quality first-surface optical flat star diagonal.
For Schmidt-Cassegrains #8772 ***$109*** (3.45)

Sky Wizard™

Electronic Finder & Sky Catalog

Let Sky Wizard do the work, while you relax and have fun observing!

- Find any celestial subject in 15 seconds!
- One minute set-up – no polar alignment or levelling.
- Observe hundreds of objects in a few hours!
- For ANY telescope, with or without a motor drive. Even altazimuth or Dobsonian scopes!
- Digital display of celestial coordinates (RA & DEC).
- Built-in electronic sky catalog – find subjects by their common catalog name, not their coordinates. Complete with object descriptions.
- Powered by a single 9v battery. Weighs just 6 oz!

Sky Wizard Model 1
Includes the Messier Deep Space Catalog of 110 objects, 28 bright stars, and the planets.
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seeing this iron line coming from a region so close to the black hole where relativistic effects are important is new," says Columbia University astronomer Jules Halpern. "This will allow us to see details in the disk structure never seen before." The ASCA group, led by Yasuo Tanaka of the Japanese Institute of Space and Astronautical Science, report details in the June 22, 1995 *Nature*.

Microwave Outburst Caused by Shoemaker-Levy 9

Before Comet Shoemaker-Levy 9 crashed into Jupiter in July 1994, astronomers predicted that dust in the comet would reduce radio emissions from Jupiter. But the comet had the opposite effect: A dramatic outburst of microwaves occurred during the six-day long bombardment.

A team of 27 researchers, led by Imke de Pater of the University of California at Berkeley, observed the microwave outburst with a global network of 11 radio telescopes. Reporting in the June 30 issue of *Science*, the researchers speculate that the outburst may have resulted from energetic electrons being redistributed in Jupiter's immense magnetic field. They hope to use their data to better understand how these electrons get energized and move in Jupiter's radiation belts.

Solar Probe Heads North

In the spirit of its legendary Greek namesake, the solar probe Ulysses continues to explore the hidden sides of our Sun. On July 31, the joint NASA/European Space Agency spacecraft passed a point 80.2° north of the solar equator, giving astronomers a view of the Sun never before seen. Up to now, studies of the Sun have focused on regions around the equator. Since its launch in October 1990, Ulysses has reconnoitered both polar regions from a 176-million-mile orbit above the Sun.

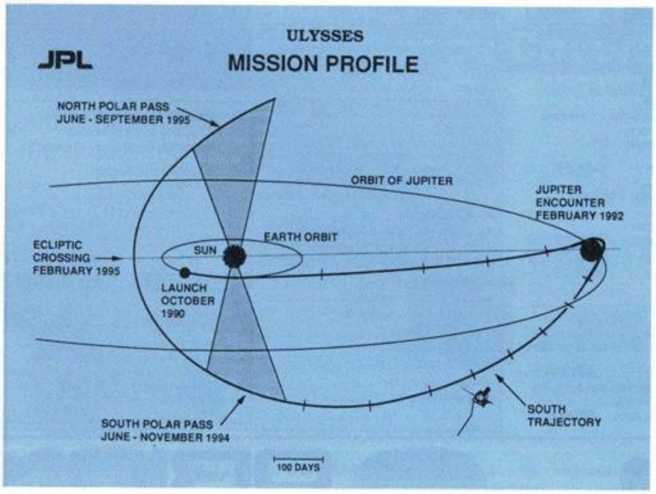
Ulysses does not take pictures, but monitors the Sun's charged particle streams and magnetic fields. Last year's passage above the southern pole revealed how the Sun's "wind" of charged particles varies with latitude. Specifically, polar wind speeds are double those found at the equator. These winds carry about one million tons of material from the Sun each second.

Since crossing the equator heading north, Ulysses has landed a satisfying discovery and hatched a mystery. In July, astronomers announced that the spacecraft's particle detectors found evidence of very low frequency oscillations, not unlike sound waves, coming from the Sun's center. The long-sought oscillations have periods of up to three hours. Solar astronomers have been using higher-frequency oscillations for almost 20 years to deduce the Sun's interior, much like terrestrial seismologists deduce the Earth's interior by studying earthquakes (see "Journey to the Heart of the Sun," January, 1995). The newly-discovered longer oscillations might someday let latter-day "helioseismologists" plumb even deeper into the Sun's interior.

As for the mystery, observations by Ulysses show that electrical and magnetic fields responsible for regulating the behavior of solar wind in the Sun's northern regions differ significantly from those in the south. Scientists will collect data on this enigma through October before the craft's elongated orbit carries it away from the Sun. Ulysses won't return to Sol's polar neighborhood until September 2000 for an extended mission that's yet to be announced.

Reginald J. Dufour, Rice University

YOUNG STARS FROM OLD GAS seems to be the case with IZw18, a blue dwarf galaxy recently studied with the Hubble Space Telescope. Reginald J. Dufour of Rice University and his collaborators found that stars appear to be forming in the galaxy, which has the lowest ratio of oxygen to hydrogen of any known galaxy now forming stars. This suggests the stars are forming from hydrogen gas that has remained pure since the earliest days of the universe.



JPL

THE JOURNEY TO AN UNDISCOVERED SUN began with Ulysses' launch five years ago. After getting a helping fling by Jupiter in 1992, the probe explored the Sun's polar regions in 1994 and 1995.

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F. HEIDE and **F. WLOTZKA**, both, MPI für Chemie, Mainz, Germany

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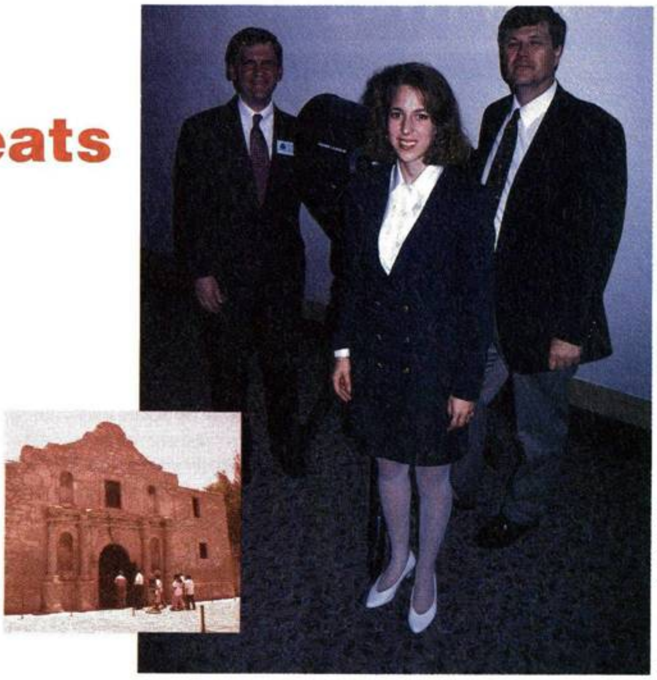
ALCON Heats Up in San Antonio

More than 200 members of the Astronomical League, the nation's federation of astronomical societies, banded together in San Antonio, Texas, from July 20 to 23, 1995. Paramount on meeting chairman Bob Gent's agenda was a series of talks by amateur astronomers covering a broad range of observing and astrophotography, council meetings of the League, a session of the International Occultation Timing Association, and the 1995 issuance of the Astronomical League awards for outstanding amateur astronomers.

Most of the talks occurred at St. Mary's University, where attendees sampled such diverse topics as Tim Hunter's update on light pollution, Tom Arnold's results from using a Cookbook 245 CCD camera, and Bill Wren's description of the automated supernova search telescope at McDonald Observatory.

Other talks focused on events of recent months or soon to come. Philip Budine described observations of the comet crash sites on Jupiter. ASTRONOMY columnist Debbie Byrd described her recent trip to Anarctica to observe the southern sky. Frank Bash, director of McDonald Observatory, outlined the progress on the Hobby-Eberly Telescope, an 8-meter instrument slated for first light in 1996.

While not in sessions, ALCON astronomers appreciated the Republic of Texas by visiting the Alamo, stayed cool by hailing a water taxi beside the city's riverwalk, enjoyed the oceanic wonder of Sea World, and dined atop the Tower of the Americas. To cap off the proceedings, on Saturday evening, well-known astroimager Don Parker of Coral Gables, Florida, delivered a talk on his experiences with CCD and the high-tech future of amateur astronomy.



ASTRONOMY: David J. Eicher

THE NATIONAL OUTSTANDING YOUNG ASTRONOMER AWARD was presented to Heather Castellano, whose project on impact cratering won a 10-inch Meade telescope. Castellano poses here with Chuck Allen (left), chairman of the award committee, and Sheldon Faworski, representing Meade Instruments. When not listening to talks, ALCON attendees remembered the Alamo (inset).

Perhaps the League's proudest moment was the celebration of the 1995 National Outstanding Young Astronomer. Chuck Allen, vice president of the League and chairman of the award committee, presided over the ceremony that honored the most promising young person's project in astronomical research. Heather Castellano of St. Hedwig, Texas, won the award for her project simulating impact cratering of planetary surfaces. Castellano's project netted her not only the award, but a 10-inch Meade SCT donated by the California telescope manufacturer. For more information on the NOYAA program, contact Allen at 1007 Rollingwood Lane, Goshen, KY 40026, (502) 228-3043.

Next year's meeting will take place in Rockford, Illinois.

Universe Smacks into Capitol

Hundreds fled to College Park, Maryland, when the Universe hit the east coast. But instead of cosmic doomsday, they found UNIVERSE '95, a two-day festival of astronomy sponsored by the Astronomical Society of the Pacific and ASTRONOMY magazine. Exhibits by leading telescope manufacturers, astronomical software developers, book dealers, and national observatories filled a large ballroom on the campus of the University of Maryland. Two dozen professional astronomers spoke about the latest topics in astronomy such as Hubble Space Telescope results, the next century in space, the future of the universe, the private lives of stars, and Comet Shoemaker-Levy 9's impact on Jupiter.

Several nationally recognized amateur astronomers also presented featured talks. Jack Newton described his latest attempts at imaging deep-sky objects with CCD cameras. Glenn Gombert discussed CCD imaging in the infrared to avoid obscuring dust in objects like the Orion Nebula. Veteran eclipse chaser Fred Espenak detailed the adventures encountered while seeking the magical minutes of totality during a solar eclipse. ASTRONOMY's Dave Eicher and John Shibley shared the latest and hottest images of deep-sky objects and down-to-Earth advice on buying a telescope.

Plan to join the festivities next year when UNIVERSE '96 comes to Santa Clara, California, on the weekend of June 22 and 23. ☐

CHECKING OUT THE LATEST SCOPES, books, and accessories was part of the fun last June at UNIVERSE '95 for more than 500 amateur astronomers in the Washington, D.C., area.

ASTRONOMY: John Shibley

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For more information on Venus Multiprobe, visit the Internet homepage at
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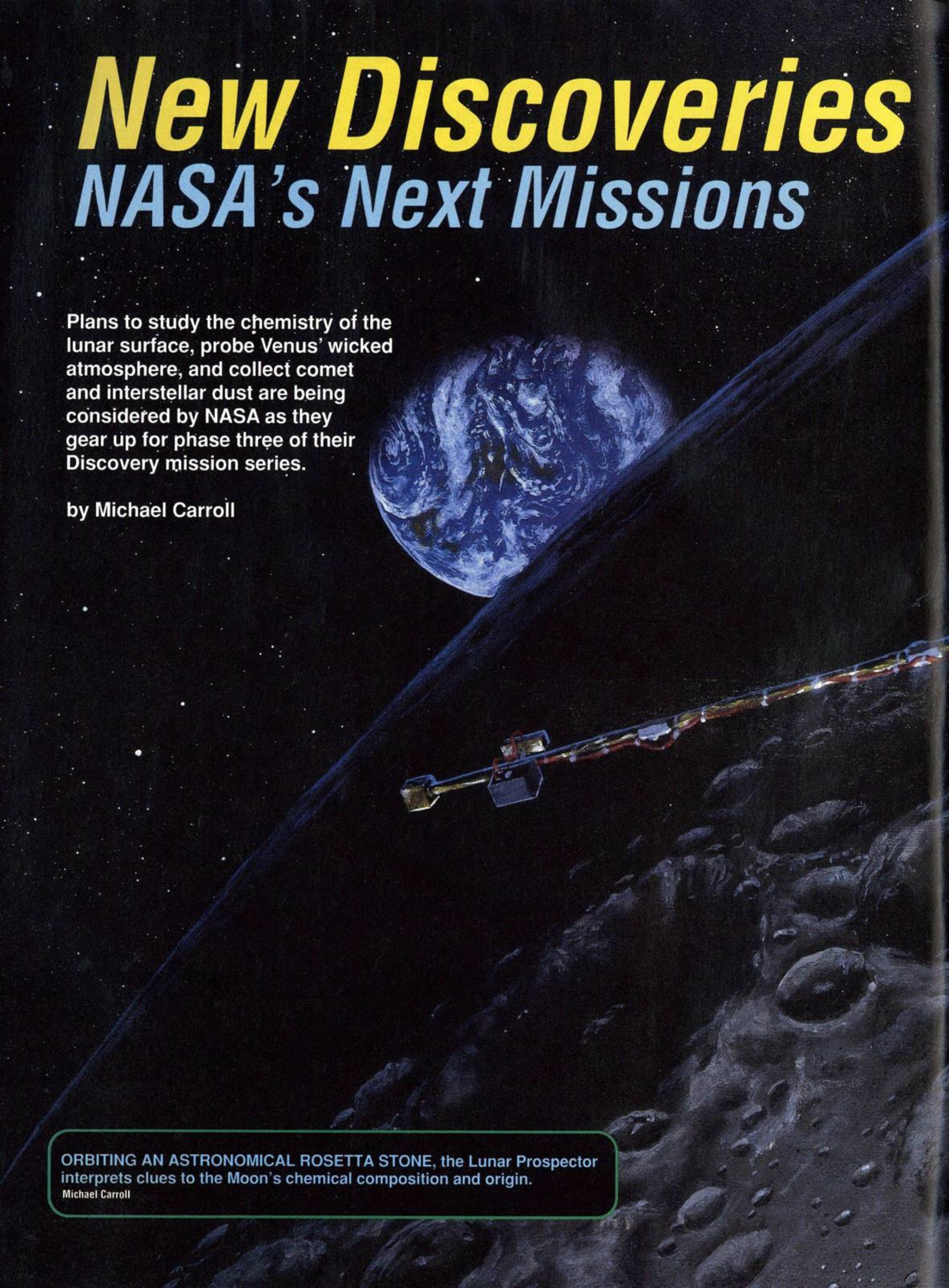
New Discoveries
NASA's Next Missions

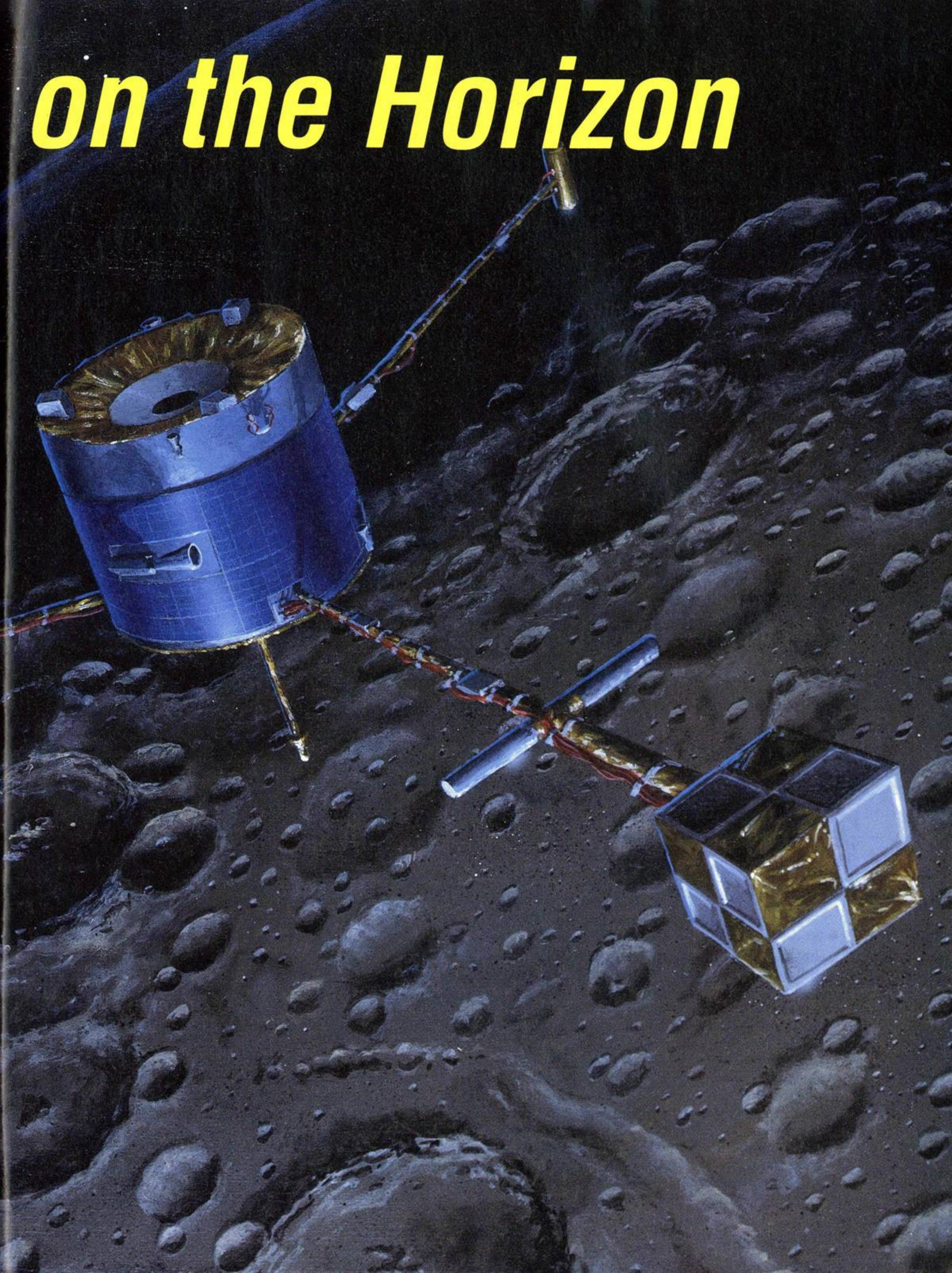
Plans to study the chemistry of the lunar surface, probe Venus' wicked atmosphere, and collect comet and interstellar dust are being considered by NASA as they gear up for phase three of their Discovery mission series.

by Michael Carroll

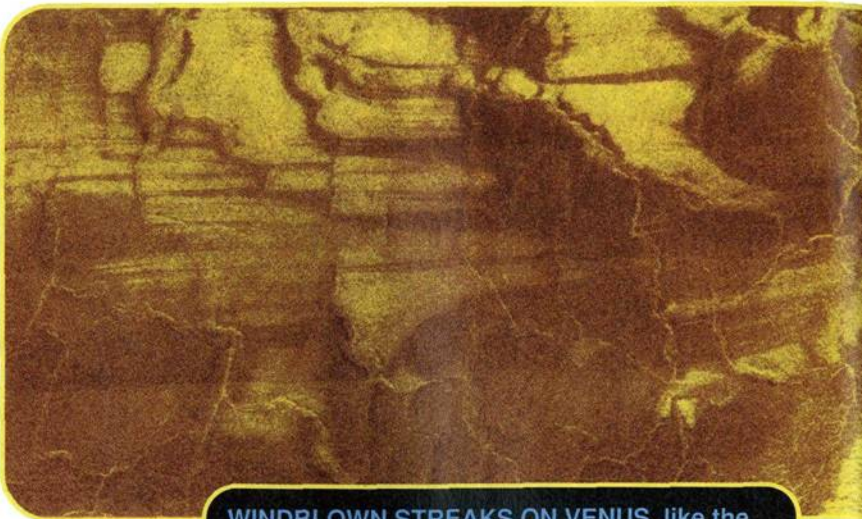


ORBITING AN ASTRONOMICAL ROSETTA STONE, the Lunar Prospector interprets clues to the Moon's chemical composition and origin.
Michael Carroll

on the Horizon



The Rosetta Stone is a glistening black basaltic slab inscribed with what was once considered inscrutable engravings. Discovered in 1799, it remained an enigmatic puzzle until 1822, when the French scholar and linguist Jean-François Champollion announced that he had cracked its code. Thereafter, the Rosetta Stone became the key to deciphering Egyptian hieroglyphics and understanding the history and culture of another time.


WINDBLOWN STREAKS ON VENUS, like the ones seen in this Magellan image, may lend insight into what causes Venus' winds to whip around the planet every 90 hours.

Ron Greeley, Arizona State University

Nearly two centuries later, another basaltic Rosetta Stone waxes and wanes in the night skies of Earth, and it's staring back at Alan Binder. Binder is the Principal Investigator for the Lunar Prospector, the newest of NASA's touted Discovery missions. "The Moon provides a window into the past," Binder says. "It is a key to understanding the early stages of planetary development. There is an incredible history preserved there. Also, there is implanted solar flare material in the soil, so we have the history of the Sun recorded there. The Moon is, in a sense, many Rosetta Stones."

There are other cosmic Rosetta Stones out there waiting to be decoded. Two of NASA's Discovery missions typified by this theme are already well into development. They are Mars Pathfinder and the Near Earth Asteroid (NEAR) spacecraft. The upcoming Lunar Prospector will be NASA's third funded Discovery mission. It is hoped at least one more will follow.

Three other low-cost missions are currently being considered for follow-up studies: comets, interstellar material, and the atmosphere of Venus. The selection of one of these proposals will take place later this year. While NASA is deciding which one to select, Lunar Prospector is being readied for a 1997 launch.

Lunar Prospector

Lunar Prospector's complement of five science experiments promises to fill in many of the knowledge gaps that we still have about the Moon. Those gaps are, in some cases, extensive.

"The surface of the Moon is equal to North and South America," says Binder. "That's a lot of land mass. We've just scratched the surface." The Lunar Prospector mission follows on the coattails of the Jupiter-bound Galileo spacecraft and the Clementine lunar orbiter, both of which mapped various regions of the Moon and addressed several science objectives outlined in a landmark study by NASA's Lunar Exploration Science Working Group (LExSWG).

Coming in at just under $59 million, including launch vehicle, Prospector is a mission with a high science value for a low cost. At mission's end, scientists will map the Moon's chemical composition and magnetic and gravity fields at unprecedented resolution. To do this, the spin-stabilized craft will scrutinize the lunar surface from a mapping altitude of 100 km, scanning with state-of-the-art science instruments.

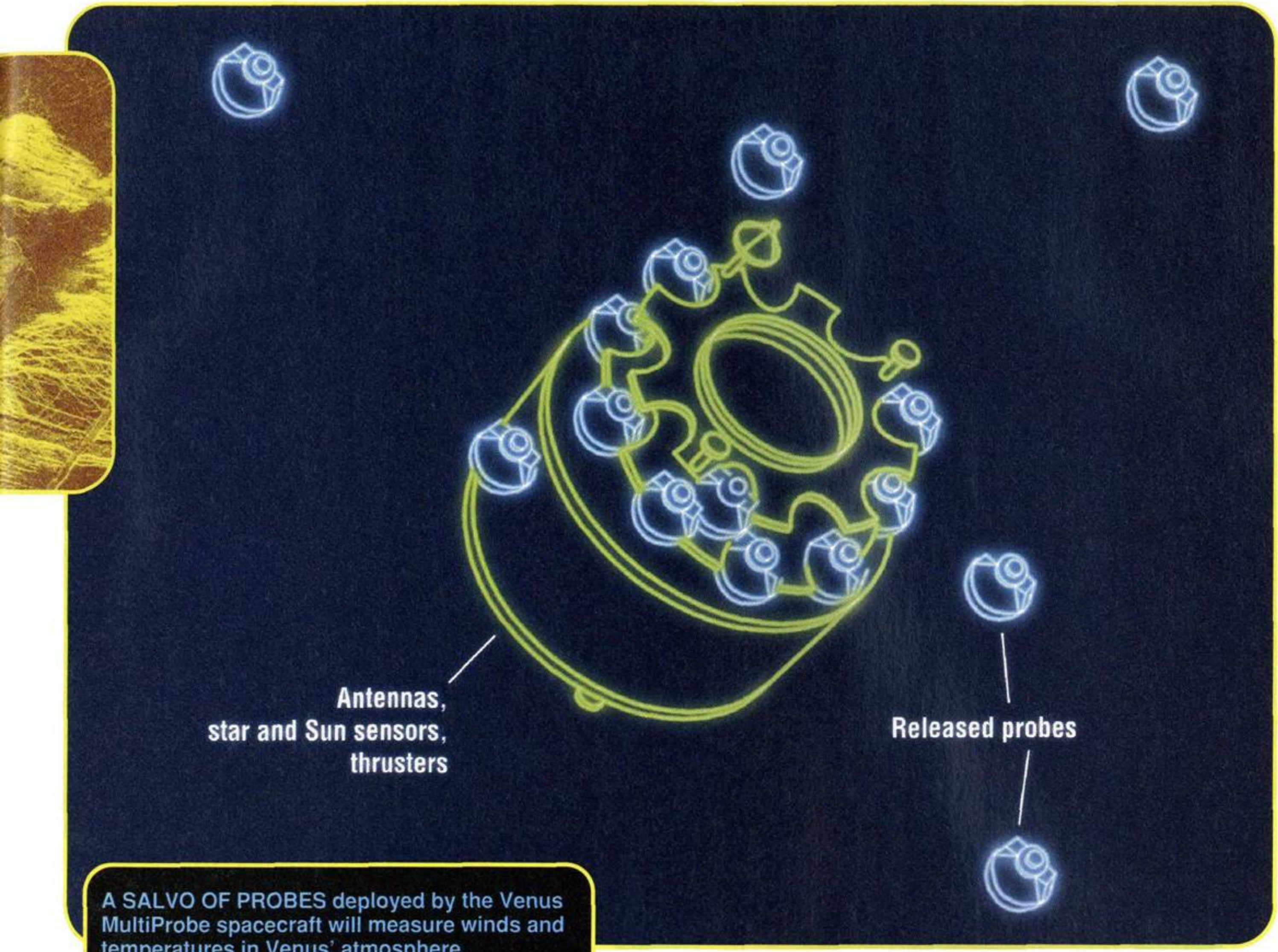
PROSPECTOR will scrutinize the Moon with state-of-the-art instruments from an altitude of 100 km.

Within the constraints of Discovery mission weight and cost, some compromises were made on two experiments, but not on the others. The gamma-ray spectrometer, for example, is a simple version of more complex spectrometers. "We are flying a spectrometer which does not require cooling, and it's inexpensive compared to a germanium spectrum," explains Binder. "It does not complete the gamma-ray objectives (of the LExSWG), but we're getting a lot of very good data."

The neutron spectrometer, which will map hydrogen distribution, is as good as you can get, says Binder. "There's no way of doing it better. We will nail that down, dead; that's finished. You'll never have to fly another one again."

One by-product of the gamma-ray spectrometer and the neutron spectrometer data will be resolving the issue of whether water ice has survived within permanently shadowed zones near the lunar poles. In 1989, radar bounced off the polar regions of Mercury carried a surprising signature: the telltale sign of frozen water. Studies indicate that ice may cling to the floors of deep polar valleys and craters on Mercury. Polar regions on the Moon are not accessible to Earth-based radar, but Prospector will be able to see into these deep areas, searching for ices that may have been laid down millions or even billions of years ago.

Any existing lunar outgassing will be searched for using Prospector's alpha particle spectrometer, which will provide not only information on the frequency but the location of outgassing events. Although the spectrometer is a good one, says Binder, "the only problem with [it] is that you're looking for transient events. No matter how well we do this, we'll still want more time. It's like sending up a weather satellite, taking a snapshot, and saying 'Well, that's it.' You have to monitor over a long period


Antennas, star and Sun sensors, thrusters
Released probes

A SALVO OF PROBES deployed by the Venus MultiProbe spacecraft will measure winds and temperatures in Venus' atmosphere.

Phil Kirchmeier

of time."

Binder points out that the alpha particle spectrometer will measure the current level of activity. "That's extremely important," he says. "You are getting information on what the moon is doing, not just what it's made of or its characteristics."

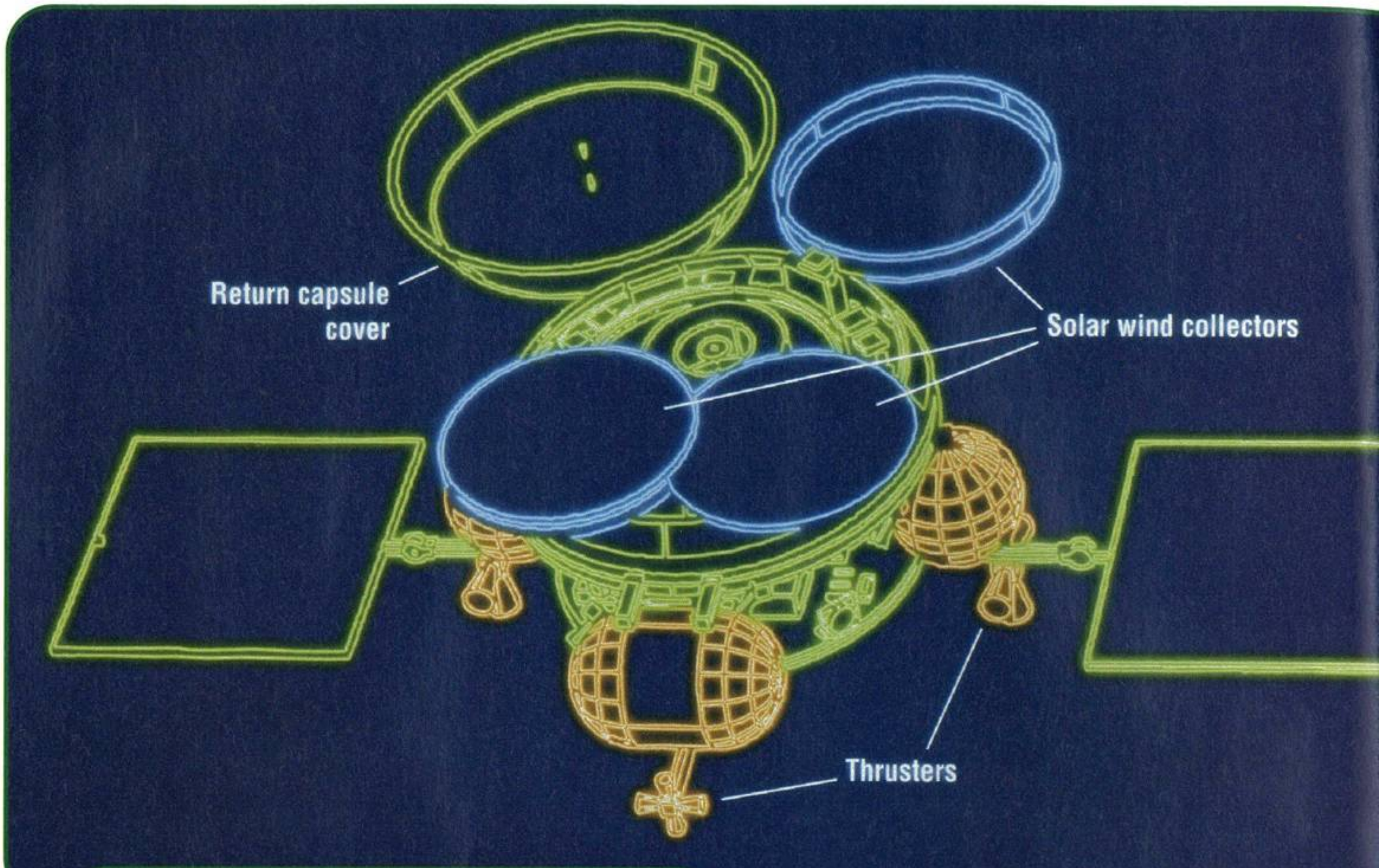
The first global maps of the lunar crustal magnetic fields will be produced by the magnetometer and electron reflectometer. The lunar magnetic fields have been a mystery for quite some time. Prior to the Apollo expeditions, it was suspected that no global magnetic field existed on the Moon.

When the Apollo teams set up magnetometers on the Moon 25 years ago, researchers discovered small, localized magnetic fields. The question that still haunts them is: where does this magnetism come from? Some scientists believe the Moon had a magnetic field in its earliest epoch. Rocks were magnetized as they cooled. If there was a dipole field (i.e., a magnetic field with a north and south pole similar to Earth's), then this would explain the magnetism in the rocks. A second theory is that when impacts occur, a plasma forms. This plasma traps the solar magnetic field. The rocks become magnetized as they cool.

"It appears that there is a correlation between large impacts and magnetic fields," Binder says. "What needs to be done is to map the distribution of the fields and their orientation and field strengths. Then you can determine whether or not they are caused by something other than a dipole; something like impacts."

In addition to these experiments, Lunar Prospector's Doppler gravity experiment will provide gravity maps that, when combined with topographic data from Clementine, will greatly increase our understanding of the structure of the Moon's crust. The gravity maps will reveal details about the lunar crust and the substructure of impact basins. Data may also improve our understanding of a lunar core, if it exists.

Another lunar mystery Prospector promises to unravel is that of KREEP, which stands for K-potassium, Rare Earth Elements, and Phosphorus. Planetary geologist Ron Greeley of Arizona State University believes that KREEP holds the key to the Moon's past. "This is material that is part left-over from the global magma ocean, and the Prospector Mission enables us to map KREEP over the entire Moon rather than just in the equatorial regions that Apollo covered. It relates to the earliest history of the Moon." Greeley and other scientists see a difference in KREEP abundances when comparing lunar near-side and far-side terrain. "The KREEP compo-



X-ray Sun, Institute of Space and Astronautical Science/NASA

nent is a reflection of what happened early in the history, and most of the near side is covered with the lunar maria, which are the younger elements of the geological record. The far side is composed mostly of highlands, and they date, as nearly as we can tell, from the early accretion period. The maria come along about a billion years later. Lunar Prospector will map the whole globe to see exactly how the different areas interrelate in age."

With its battery of scientific instruments, the diminutive Lunar Prospector promises to unlock many of the Moon's carefully guarded secrets. If all goes as planned, LExSWG's wish list of things to discover may have many of its items checked off very soon. The Galileo flyby and the Clementine mapping mission began the modern scrutiny of our nearest neighbor, addressing many of the LExSWG's questions. Wesley Huntress, head of NASA's Solar System Exploration Division, sums it up succinctly: "Lunar Prospector proposes to do all the rest."

Mission to Venus

After Lunar Prospector, NASA is setting its Discovery sites farther afield by evaluating the viability of three proposals that would travel far beyond the Moon. All three were culled from several hundred proposed missions, all of which cost less than $150 million, including a small launch vehicle.

One of these endeavors — called the Venus Multi-Probe Mission (VMPM) — would attempt to solve one of the great mysteries in solar system studies: the workings of the dense, harsh atmosphere that swirls around Venus. With a density 80 percent of Earth's, and a diameter of 12,104 km — 652 km less than Earth's — Venus is practically an Earthly twin. But its environment is alien and hostile. Its atmospheric pressure, 90 times that of Earth's at sea level, traps solar energy, which bakes the surface at 482° C (900° F). The primary goal of VMPM is to understand the strange global circulation of the planet's atmosphere.

Venus rotates in a retrograde (east-to-west) motion, which is the opposite rotational direction of Earth. A day on Venus is equivalent to 243 Earth days. Its atmosphere, though, rockets around the planet once each 90 hours, 60 times faster than its rotation. This atmospheric

PANNING FOR SOLAR PARTICLES, the Suess-Urey mission will employ huge panels (pan-shaped details in this diagram) designed to catch different types of solar particles. The purpose: to return bits of the Sun to Earth for analysis.
Jet Propulsion Laboratory

phenomenon is called "superrotation." Since its discovery, finding an explanation for superrotation has been on the agenda of every Venus mission. Despite the fact that Pioneer Venus sent four probes into the planet's caustic atmosphere, and an entire series of Venera landers were deployed on Venus by Russia, superrotation has remained a mystery.

Says Richard Goody, VMPM principal investigator at Harvard University, "It's a very surprising thing. We are concerned with why we cannot answer this question, because it bears upon the understanding of our own atmospheric dynamics."

Goody explained that this strange phenomenon originates about 20 km above the planet's surface, far below the 50-km to 70-km altitude where most solar energy is absorbed. This fact leads researchers to believe that the dynamic processes that occur in the lower atmosphere are fundamental to Venus' global circulation. This region has not been studied in detail by any of the previous probes and landers. To understand the wind and thermal structure in the deepest regions, much data has to be obtained at the same time. The VMPM proposes to do just that.

Based on the mission design for the probes of the Pioneer Venus mission, which successfully deployed four probes into the acid-laden clouds in 1978, VMPM will carry more probes and make more accurate wind, pressure, and temperature measurements in the upper clouds of Venus. The flotilla of probes, 14 in all, will paint a detailed portrait of the deep atmosphere, where Pioneer Venus temperature measurements failed, and where winds were too weak to be measured. Venera data in this region are not accurate enough for detailed models, either, so VMPM will be trailblazing into unexplored territory.

WHAT SECRETS lie at the heart of the Sun? The Suess-Urey spacecraft will find out.

Current plans call for VMPM to be launched on a Delta II, arriving at Venus on September 19, 1999. Thirty-seven days prior to arrival, the first salvo of seven probes will be deployed. Twenty-one days later, the remaining seven probes spin off the main craft. The two salvos will arrive within about 2 hours of each other, forming a giant bulls-eye pattern of two concentric circles across the face of the planet. Each descent takes about an hour. Earth stations all over the world will carefully listen to radio beacons from each probe. Subtle changes in the frequency of each transmitter will enable researchers to determine vertical temperature profiles and wind direction and velocity, data critical to understanding superrotation.

Another clue to the nature of Venus' winds can be found in Magellan radar images, says Ron Greeley. Greeley is a project scientist on VMPM, and has been studying Magellan images of wind-blown areas on the surface of Venus. "We want to compare the wind streaks in Magellan images with current wind patterns," he explains. "This will show us whether the surface features we see are fossil, or reflect modern patterns. How has the planet's atmospheric circulation changed over time, if at all? Does it coincide with what we see on the surface? Any result we get will be very interesting."

Two other critical elements are included in the project. The second component of the mission is a theoretical modeling program that will enable the detailed probe observations to be related and interpreted in physical terms. "These phenomenon are incredibly complex," says Richard Goody. "We must develop a reasonably accurate model to interpret them."

The mission's third component is a ground-based observational program that will chart the deeper portions of Venus' atmosphere in the infrared. "We would like to set the probes in a context of time and space," Goody explains. With the interrelationship of ground-based observation, mathematical modeling, and probe data, Goody's team believes they can finally derive a realistic explanation for the causes of Venus' great atmospheric mystery, and, in so doing, shed light on the workings of other atmospheres, including our own.

To Catch the Sun

Another Discover group proposes a mission to capture material from the heart of the nearest star, our Sun. Suess-Urey (SU) mission features a six-month flight path to the L1 Sun-Earth libration point, an area about 1,610,000 km from Earth toward the Sun. For two years it will collect solar wind ions, then return them to Earth. (Libration points are regions in space where a small object can maintain a stable orbit indefinitely despite the gravitational pulls of two more massive bodies that are in orbit about a common center of gravity. L1 represents the point between Earth and the Sun.)

The small spinning spacecraft has panels that will swing open to catch several different types of solar particles. The Sun emits different types of material at different times. Ground-based observers will monitor the Sun, and will choose among three different types of collectors that will sweep up varied types of solar material, depending on the Sun's activity. Panels will be deployed or stowed many times during the mission in order to collect solar particles with differing characteristics.

Ben Clark, engineer and scientist at Lockheed/Martin in Palo Alto, California, has been working on two Discovery-class mission proposals. Clark recently outlined the Suess-Urey's unique collector system. "These panels are over half a meter across, which means we have a total collection area of over a square meter. These are actually made of little wafers of ultra-pure silicon and ultra-pure germanium. We call it the pepperoni pizza design. After two years, these are all retracted and folded down inside, and the lid goes on to seal in the samples."

Maintaining the integrity of the samples is of paramount importance in the design, says Clark. It is

SWEEPING UP COMET DUST for study on Earth is the goal of the Stardust mission, planned to launch in February 1999.
Peter Tsou, Jet Propulsion Laboratory

Max-Planck-Institut für Aeronomie

imperative that nothing contaminates the solar particles. With this in mind, engineers and flight designers sought help from NASA's Johnson Space Center, which gained much experience containing and analyzing Moon rocks in a safe, contaminate-free environment. It is at JSC that the samples will be studied initially.

Once the craft is stabilized at the L1 point, the collection of solar material can begin. "We collect for two years, close it up, and seal it," Clark says. Then the craft makes the six-month journey back home with its valuable cargo. But the challenges are not over. As it enters Earth's atmosphere at 38,000 kph, the craft must keep samples in and terrestrial gases out. To retain the integrity of the interior, ultra-pure helium is pumped through the craft to keep it pressurized so no air gets in.

The last hurdle is landing, which can be fairly violent even with a parachute. The mission calls for recovery before the craft actually touches down on terra firma. "As it comes down through the air on parachute," Clark explains, "the plan is to fly helicopters past it to grab it so it doesn't hit the ground. We don't want to run the risk of breaking it open. Then it will be taken to JSC immediately, put into a clean area, and then they'll open it up."

Suess-Urey is a three-year mission, but most of the real scientific work will take place in laboratories all over the world for years to come. Clark anticipates a furious dash on the part of the scientific community to obtain the precious particles. "People will write proposals and say 'Give me ten particles for such and such.' Someone will have to decide which researchers get what, and that could be an involved and difficult procedure, but it's been done before."

The principal investigator for Suess-Urey, Don Burnett of Caltech, says "Let me do this mission, and I won't ask for another mission for a hundred years."

COMET AND COSMIC DUST provide vital clues to understanding the nature and evolution of the solar system.

Cosmic Dust Buster

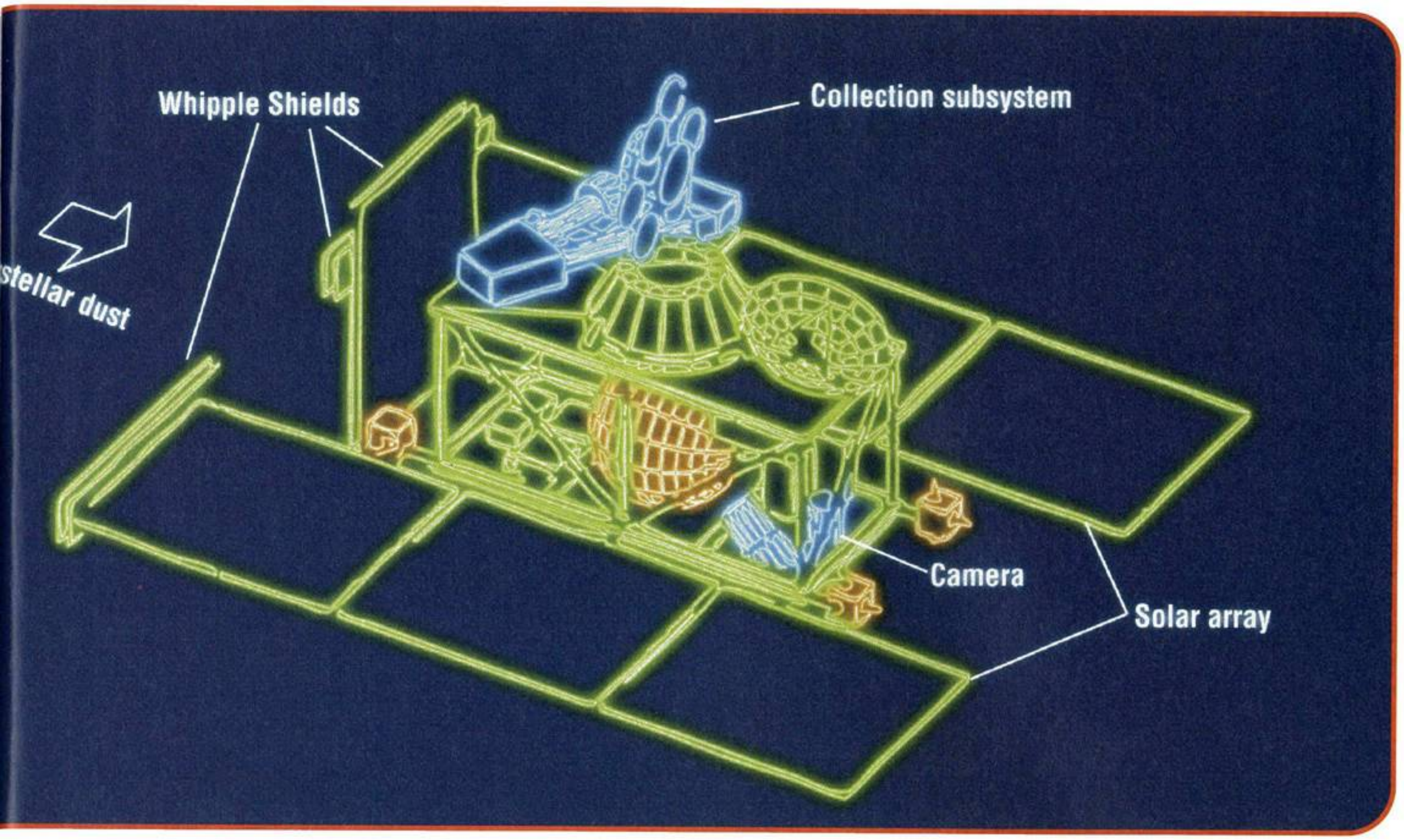
The final Discovery-class mission under consideration would study more distant objects. Stardust is a low-cost project with high goals: to return samples of a comet and to gather particles that come from far beyond our solar system.

In 1993, the international Ulysses solar probe discovered a stream of interstellar dust moving through our solar system. These observations were confirmed by the Jupiter-bound Galileo spacecraft. Principal Investigator for Stardust, Don Brownlee of the University of Washington, Seattle, explains, "It appears that this interstellar material is streaming into our solar system, but it's really a matter of the velocity of our system moving through space. This is true interstellar dust, which ultimately came from other stars."

In addition to collecting extrasolar material, Stardust will take advantage of a 1974 Jovian gravitational deflection of comet P/Wild-2 out of deep space. The comet's new path brings it into an orbit that can be met by the Stardust craft at fairly low velocity. The lower the relative velocity is, the easier it is to capture intact particles from the comet.

In order to accomplish its multiple goals, Stardust will do a series of Earth swingbys. Its orbital path sends the craft into long loops that are oriented away from the direction of incoming interstellar dust. As Brownlee says, "On part of these loops, the spacecraft trajectory is going in the same direction as the flux of interstellar dust coming into the solar system. With the spacecraft traveling in roughly the same direction, this minimizes the relative impact velocity." Interstellar particles come into the solar system at about 26 km/sec. By using this trick of collecting particles while moving away from the point in space where the interstellar particles are coming from, the impact velocity can be reduced to between 10 and 20 km/sec.

"We're going to do the best job we can in collecting interstellar grains, " says Brownlee, "but it's a very difficult thing to do. We don't even know what interstellar dust grains look like. They are smaller than comet dust and they're coming in at higher speeds. We know they'll hit the collectors; we know they'll go into the collectors; but how much we'll be able to do with them



we really don't know." The scientific return hinges on how well preserved the particles are, he added.

The key to particle capture is a material called aerogel. Invented in the 1930s at Stanford University, aerogel is a lightweight silica-based material. Its low-density and fine-porous property makes it ideal for capturing high-velocity particles. The particles that enter the aerogel material are expected to stop within about 100 particle diameters — a very short distance indeed when you're talking about typical particle diameters of 1 micrometer! (Cosmic dust can be as small as 0.01 micrometer).

About midway through the mission, Stardust encounters comet P/Wild II. Because of the unique design of its collectors, they remain deployed in the same configuration, simplifying hardware and mission demands. Ben Clark explains, "We fly towards the comet with the collectors facing the other direction. The spacecraft has Whipple shields arranged so that comet particles hit the outer shield and are split into several smaller particles, which in turn hit the next shield. It is a most efficient way to protect yourself. The collectors are sticking up above the shield, so the comet dust streams into the collectors. When we get the aerogel back, we'll have comet particles on one side and interstellar particles on the other. They all get folded up and put into this capsule like a stack of pancakes. When we get back to Earth, the capsule is released and snagged in the air."

In addition to the aerogel collectors, the Stardust craft carries a complement of science instruments. A camera mounted beneath the shields will look at the comet. The spacecraft also contains a German-made particle impact analyzer that analyzes each particle on the fly. "As we go past the comet," says Clark, "we'll get both particle flux and composition, and really good pictures, and we'll get particles to take home with us."

The flight through the comet's coma will take about five hours. P/Wild 2's density and activity levels are not known in enough detail to fully predict what the passage will be like for the craft, Clark observes. "It's like driving into a hailstorm without knowing how severe the hail is going to be."

Onboard systems can stabilize the craft if it is hit hard enough to turn it, but due to Stardust's distance from Earth at the time of encounter, it takes radio transmissions 20 minutes to travel to or from Earth. Further, there is not enough propellant to make substantial course changes. Still, researchers are confident the craft will make it through intact with the world's first samples of cometary material.

Ben Clark and other members of the Stardust team expect enough cometary and interstellar material will be returned to keep many researchers busy for years to come. "We will probably get a few thousand comet particles, and we hope to get at least one hundred interstellar particles.

The value of Stardust is that the science doesn't stop in orbit. In fact, the science really begins after the return capsule arrives back home, and it could go on for decades. But judging by the sophisticated proposals now before NASA, every one of the new Discovery candidates can make that impressive claim. □

A frequent contributor, Michael Carroll is a space artist and science writer living in Littleton, Colorado.

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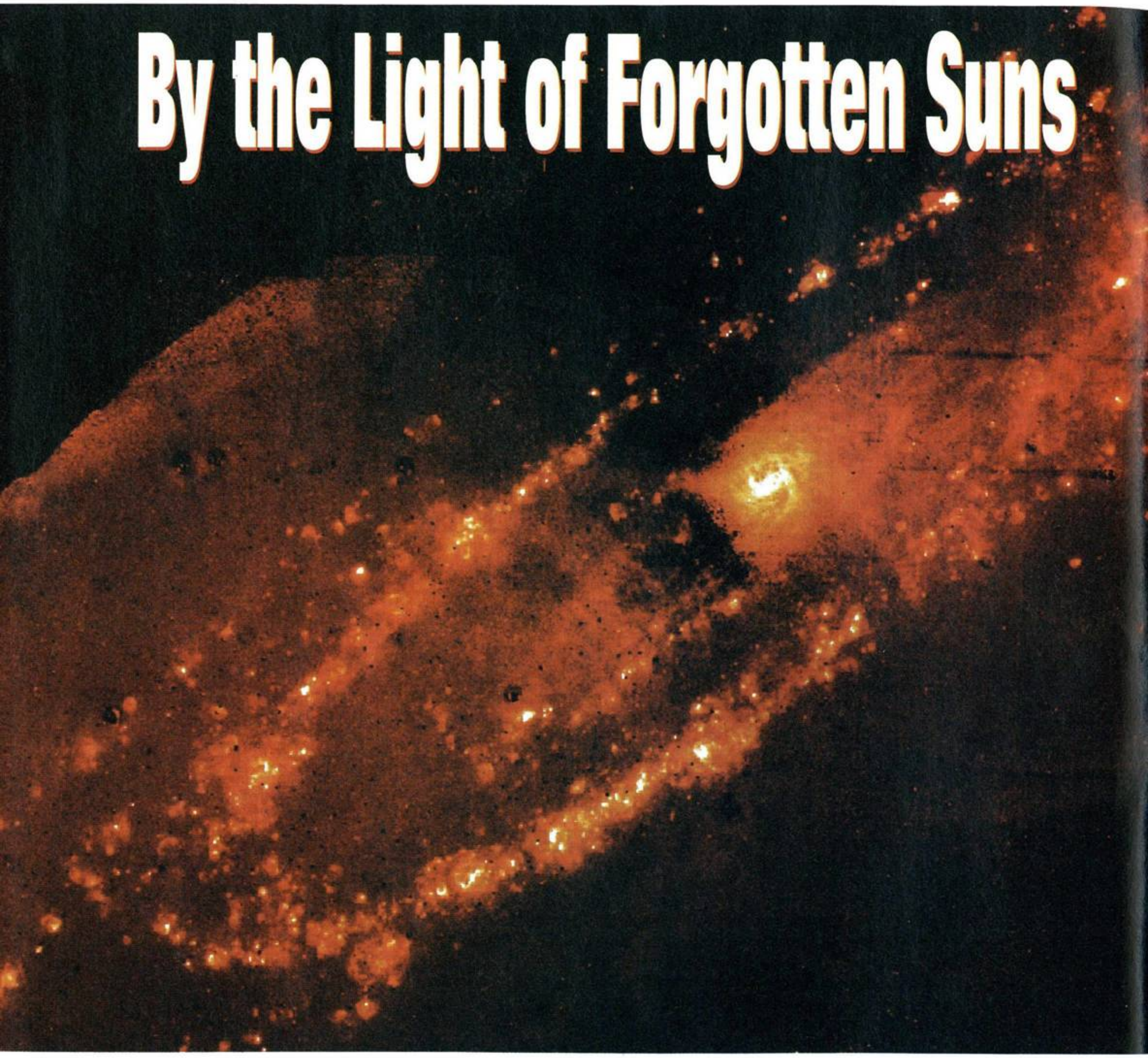


REMNANTS OF ANCIENT SUPERNOVAE trace out the spiral shape of M31. This photo, made with the 0.6-meter Burrell Schmidt Telescope at Kitt Peak, Arizona, was processed to remove most of the stars and reveal gaseous objects.

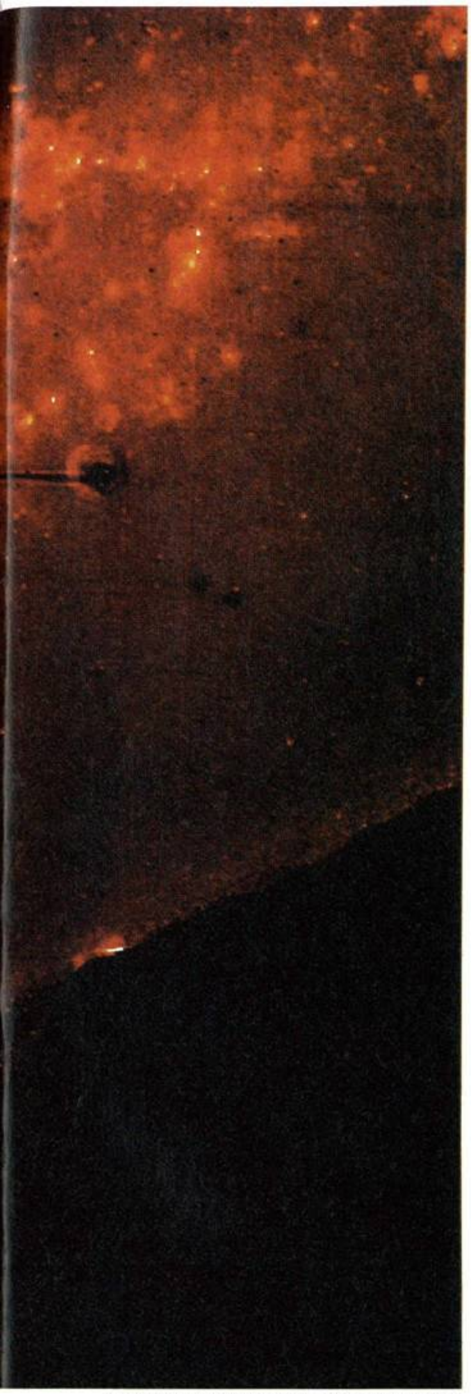
Before astronomers could sift the Andromeda Galaxy for the remains of ancient supernovae they had to turn out its stars.

by Jeff Kanipe

The old saying, "You can't see the forest for the trees" might well apply to the Milky Way's neighbor, the Andromeda Galaxy. In the past, you couldn't always see a galaxy for its stars.

But now you can. By matching up 23 overlapping CCD images, astronomer Frank Winkler of Middlebury College, Vermont, and undergraduate student Benjamin Williams have produce a wall-sized portrait of the Andromeda Galaxy, M31, with most of its stars digitally removed. What remains is the galaxy's substructure punctuated by bright clouds of gas. Some of these clouds mark the birthplaces of stars. Many, however, are remnants of supernovae, catastrophic explosions that mark the deaths of massive stars.

To reveal these never-before-seen ancient supernova remnants, Winkler and Williams used the 0.6-meter Burrell Schmidt telescope of Case Western Reserve University at Kitt Peak, Arizona. The astronomers surveyed



Ben Williams and Frank Winkler, Middlebury College

Tony and Daphne Hallas

WITH ITS STARS ON the Andromeda Galaxy takes on a more conventional, but no less striking, appearance.

M31 at wavelengths of H-alpha, ionized sulfur, and red continuum light. When the galaxy's stars were mathematically subtracted, faint ancient supernova remnants emerged.

In this new vista, the Andromeda Galaxy resembles a ring of forest fires seen from a great altitude. Each "fire" is either a supernova remnant or star-forming region. "The ratio of ionized sulfur to hydrogen-alpha is a good diagnostic for distinguishing material shocked by supernova explosions from the ionized gas around hot stars," says Winkler.

Also visible at the galaxy's center is a cyclonic conflagration containing a bright vortex with scythe-like arms: the nucleus of M31.

Not only does the panorama offer a unique perspective on the galaxy's chemical and stellar history, it demonstrates how modest, ground-based telescopes equipped with a big CCD chip can still be used to accomplish significant science.

"An object as large as M31 . . . would be too formidable to try to survey by pecking away at it a few arcminutes at a time," Winkler says. "For instance, to cover the area of our mosaic using the wide-field camera on the Hubble Space Telescope would require at least 3,000 separate pointing positions."

Although it lies a little over two million light-years away, the Andromeda Galaxy takes up about three degrees of sky — that's six Full Moons side by side. Most large ground-based telescopes can only fit a small part of it at a time into a single field of view, which is fine for revealing detail but doesn't show those details in context with the overall structure. And though wide-field cameras and telescopes may be able to take in the entire sweep of the galaxy, they cannot resolve small-scale structure. It's like trying to read an atlas map of Africa from the end of your nose or from arm's length. It's difficult to get the details and the big picture at the same time. "The galaxy is so big that we have to look at it on a large scale if we're to see everything that's there," Williams says.

The fact that M31 looms so large in the night sky results from its true size — larger even than the Milky Way. Thus, a rich variety of objects are resolvable, including supernova remnants. The challenge is separating out its stars so more of the galaxy's gaseous structure becomes evident. "Most of the light from a galaxy comes from stars," says Winkler, "and the bright starlight gets in the way where we're trying to study the fainter emission from gas clouds."

So far, Winkler and Williams have identified 110 objects that may be supernova remnants, nearly ten times the number that had previously been confirmed as such. They are revealed by their relative brightnesses at the wavelengths of hydrogen and sulfur.

Follow-up studies of the objects will require the light-gathering power of larger telescopes. "Astronomers need a variety of tools in their kit," Winkler notes. "A small telescope with modern instrumentation is terrific for the kind of survey we've done, but one also needs the power of a 4-meter, or the resolution of Hubble for probing details."

The follow-up analysis will likely take years to complete, but the payoffs are significant. "We'll be able to probe the chemical make-up of Andromeda at lots of different points, and better understand how heavy elements are made and distributed in the galaxy," says Winkler. "This fall we will be studying many of the most interesting objects from our survey using the 4-meter and the 3.6-meter WIYN Telescopes at Kitt Peak." ☐

Curtains at the Edge of the UNIVERSE

Can astronomers ever see the Big Bang that created the universe?

by Robert and Sarah Williams Scherrer

The search for our beginnings is a quest that has occupied the activities of scientists for thousands of years. A glimpse of the mighty Big Bang that astronomers believe brought the universe into existence 10 billion years ago would settle many cosmological arguments. But physical limits may be set by the very particles from which the universe grew, like curtains that will perhaps prevent anyone from ever seeing back to the beginning of time.

Explorers, both cosmic and earthly, have frequently encountered such curtains. The oceans provided a curtain blocking Europeans' view of the New World. Mappa Mundi, one of only two surviving medieval maps of the world, shows this curtain of knowledge. This map, which today lies in a cathedral nestled in the small market town of Hereford in western England, shows the world as a flat round circle with Jerusalem in the center and Europe, Asia, and Africa spread around it. These continents are badly misshapen and occupied by fantastic creatures, but perhaps the strangest feature of the map is that it ends abruptly at the edge of the circle, with nothing beyond.

Our view of the universe is not too different. The map of the "known world" ends abruptly at ten billion light-years in all directions, as if we lie at the center of a glowing spherical curtain that astronomers currently cannot see beyond. Future researchers may be able to use exotic subatomic particles to penetrate this curtain, but they will simply run into other barriers beyond it. The origin of these barriers lies at the very beginning of the universe itself.

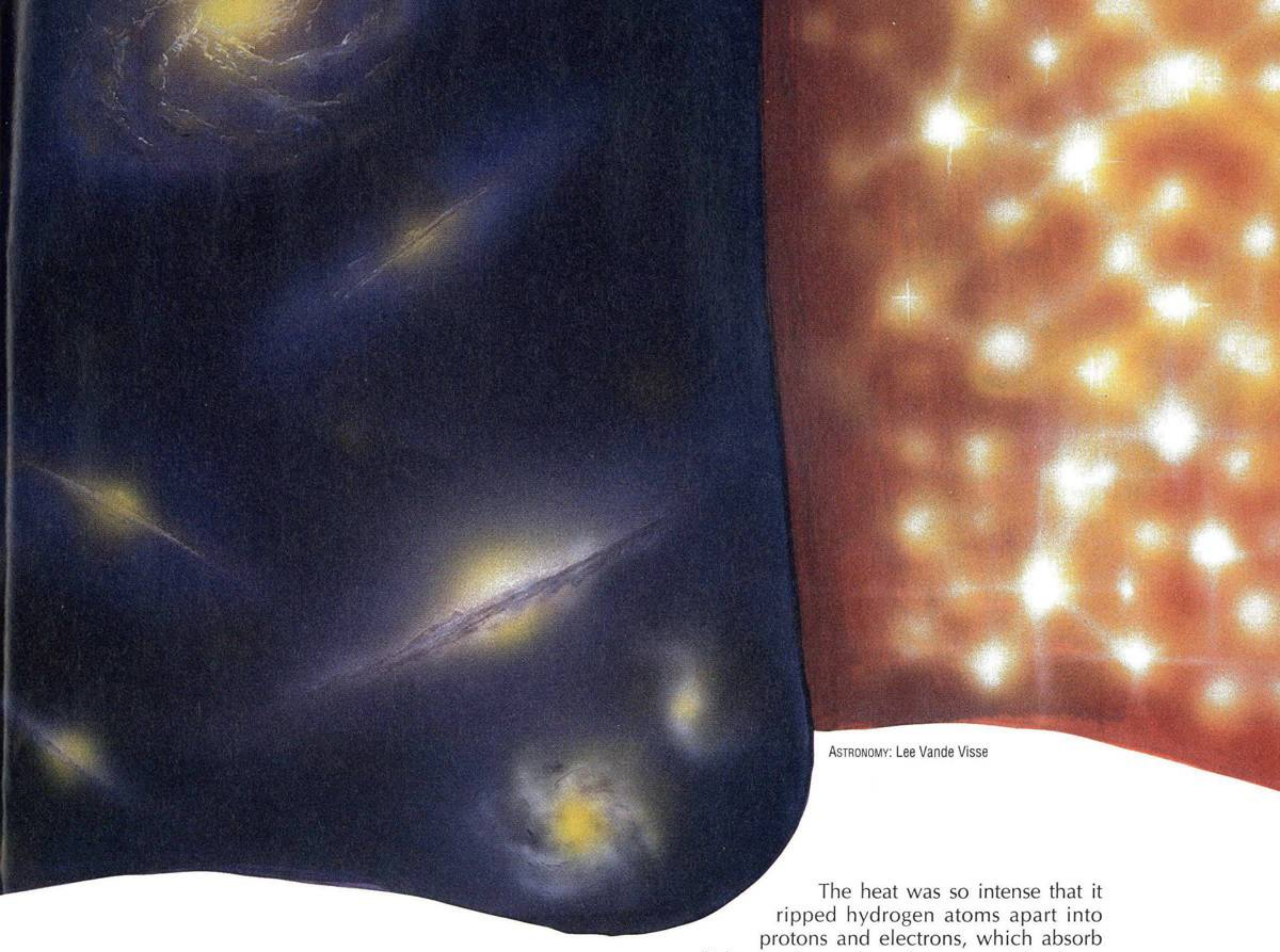
> Early in this century, astronomers expanded their vision of the universe from thousands of light-years to millions.

To part their curtain, Renaissance explorers sailed out beyond the edge of the Mappa Mundi and discovered a round world. At the same time, astronomers' view of the universe expanded as well. Instead of a cozy medieval universe centered on Earth, they discovered that Earth circled the Sun, which became just one star among many.

Until the early 20th century, many astronomers believed that the stars in the Milky Way comprised the entire universe. Only in the late 1920s when Edwin Hubble measured the distances to nearby galaxies did astronomers push out their curtain of ignorance. They learned that the Galaxy was just one among many that are separated by millions of light-years. So their vision of the universe expanded from thousands of light-years (the distance to the farthest visible stars in our galaxy) to millions of light-years (the distance to other galaxies).

During the 20th century, the view of the universe expanded not only in distance but also in the kinds of radiation that scientists could detect. Previously, astron-omers could see only visible light through their telescopes. In the 1930s while Hubble pushed back the boundary of the universe, radio engineers discovered that celestial objects emitted radio waves, giving birth to radio astronomy. Soon astronomers were building telescopes to view distant objects in all the different wavelengths of electromagnetic radiation: infrared, ultraviolet, X rays, and gamma rays.

Radio astronomers first discovered the most distant objects scientists can see — quasars, which are powerful radio emitters powered by gas that swirls around a black hole. In viewing these objects, one is looking back in time. The light from a quasar a billion light-years distant left on its journey to Earth a billion years



ASTRONOMY: Lee Vande Visse

ago, when life on Earth was just beginning to evolve from single-celled creatures.

Looking at more distant quasars enables astronomers to probe farther back in time, or closer to the beginning of the universe. But a barrier exists that prevents them from looking all the way back to the birth of time. It's an opaque curtain that no telescope yet built can pierce. No type of electromagnetic radiation — radio waves, infrared, visible light, ultraviolet, x rays, or gamma rays — can penetrate this barrier.

The barrier arose because gases in the early universe were much hotter and denser than they are today. As the universe expanded, the gases in it spread, became less dense, and grew colder. If you took all the matter in the universe now and smeared it out evenly, you'd end up with just a few atoms per cubic meter.

On our side of the barrier, astronomers can peer through space because it's nearly empty. But in the early universe, the gases were dense enough that they blocked light. If you could go back in time to a few hundred thousand years after the Big Bang, you'd find the temperature of the universe was about 3000 kelvins (5000 °F).

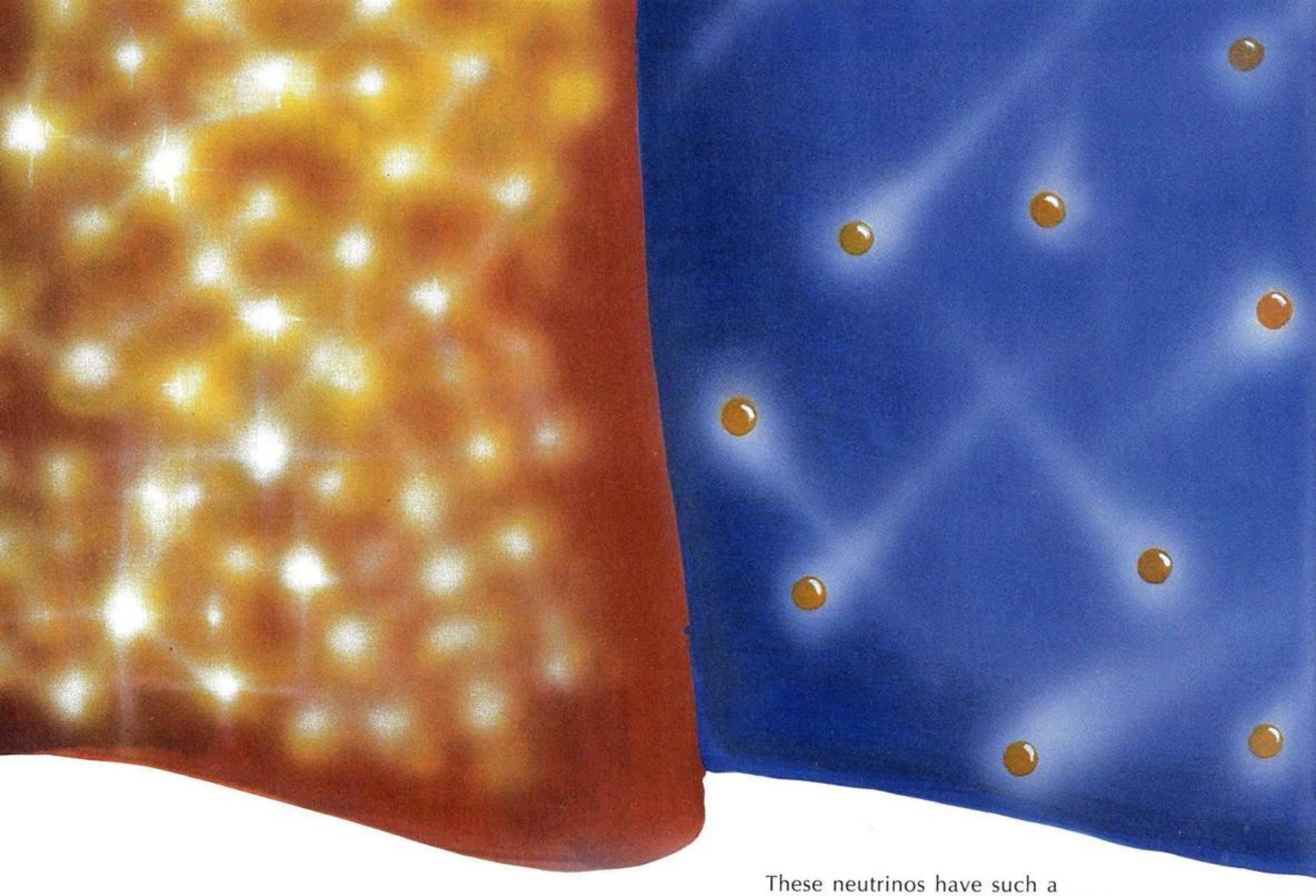
The heat was so intense that it ripped hydrogen atoms apart into protons and electrons, which absorb light even better than plain atoms. The dense gas of protons and electrons blocked light just like a brick wall. The hot gas reemitted the light evenly in all directions, forming a glowing curtain that prevented seeing through space at all.

This curtain looks like a spherical shell, extending ten billion light-years away from us in all directions. Astronomers first saw the glowing curtain in the 1960s, when they detected radiation that filled all space. The expansion of space from the time of the Big Bang caused the 3000 K radiation to cool to a mere 2.7 K. This radiation is a cosmic Rip Van Winkle produced by the protons and electrons in the glowing curtain when the universe was still an infant, and it's been traveling undisturbed to Earth for ten billion years.

A glowing curtain of light abruptly blocks our view of the universe at a distance of ten billion light-years in all directions.

In the 1990s, the Cosmic Background Explorer satellite mapped subtle patterns in the otherwise uniform radiation on this sphere (see "COBE's Big Bang" in the August 1992 issue.) These patterns provide important clues to the way that galaxies were born, so the past few years have seen a frenzy of activity as astronomers race to map the glowing curtain.

With present technology, this curtain cannot be pierced because the barrier blocks electromagnetic



radiation, which is astronomers' only means to probe celestial objects. But just as the civilization that produced the Mappa Mundi progressed beyond its limited view of Earth, scientists hope someday to pierce the barrier and see back further in time. To do this, they will have to embrace a ghostly subatomic particle called the neutrino.

Neutrinos are the phantoms of the subatomic particle world: They can penetrate almost anything without being stopped. The Sun gives off an enormous number of neutrinos, and trillions of them zip unnoticed through your body every second.

Scientists have been struggling since the 1960s to see these solar neutrinos. But detecting them is a nearly impossible job because they go right through most detectors. To catch these neutrinos, researchers have buried huge detectors made out of rare metals, water, or cleaning fluid deep underground in highway tunnels and mines. Even with these vast detectors, scientists are lucky if they capture one or two neutrinos every day out of the many million-billion that plunge right through Earth.

To see the young universe, astronomers will have to penetrate this curtain with new, exotic telescopes that see neutrinos.

In addition to the solar neutrinos, space is also filled with a mist of neutrinos left over from the Big Bang that continuously rain down on Earth,. Because neutrinos penetrate matter so easily, they can pierce the 3000 K curtain that blocks ordinary light. In fact, they come to Earth from far beyond this curtain.

These neutrinos have such a pathetically low energy (less than a billionth of the energy of solar neutrinos) that observing them has been an unapproachable goal. No detector in existence can even come close. But just as today's telescopes would have astounded Galileo, perhaps future astronomers will accomplish what seems impossible today and build a powerful enough detector to see these neutrinos left over from the early universe.

What a different view of the universe this detector would have! Instead of stars and galaxies, it would see a universe filled with a smooth gas of ions (electrically charged atoms) and electrons. Because stars produce most of the chemical elements known today, the matter in the early universe consisted of simple elements such as hydrogen, helium, and lithium. The matter wouldn't be readily apparent because packets of radiation energy called photons were denser and, thus, overwhelmed it.

At an earlier time, when the universe was less than a few minutes old, the temperature was over a billion kelvins. That was hot enough to break atoms apart into their constituent protons, neutrons, and electrons. These parts fused together when the universe was a few minutes old to make heavy hydrogen from protons and neutrons, then helium from the heavy hydrogen, and eventually lithium.

Even earlier, about a second after the Big Bang, the temperature was a whopping 10 billion kelvins. Before

this time, protons and neutrons could swap identities by exchanging neutrinos. But after that initial second, the exchanges stopped, leaving behind a sea of neutrinos.

A neutrino telescope would open up this era of the universe's history to study by astronomers. But even if scientists learn how to detect the primordial neutrinos, they won't see all the way to the beginning of time. What will stop them is a hot, intense barrier of radiation that existed in the era before protons and neutrons took on their separate identities. As penetrating as neutrinos are, even they couldn't pierce this curtain. It, too, looks like a sphere centered on Earth but more distant than curtain #1.

Too see even farther back in time, scientists must find a particle even more penetrating than the neutrino. Paradoxically, such a powerful particle may be linked to the weakest force in the universe: gravity. Although gravity is strong enough to hold us firmly on Earth, it's actually much weaker than the subatomic forces that hold atoms and nuclei together.

Researchers believe that such a subatomic particle exists. This graviton purportedly transmits the force of gravity between pieces of matter. Although no one has ever seen a graviton, scientists think they exist because Einstein's general theory of relativity predicts that masses in motion ought to give off gravitons just as charges in motion emit photons of electromagnetic radiation.

Seeing gravitons left over from the early universe is much harder than detecting neutrinos, so it's clearly a job for astronomers of the very distant future. If they could build a powerful enough graviton detector, they would be able to look back almost to the birth of the universe itself.

Scientists don't know for sure what the universe was like behind curtain #2, but they believe that many strange things happened in the first 0.0001 second of the universe's existence. Because the universe then had a temperature of over a trillion kelvins, protons and neutrons were broken apart into subatomic particles called quarks. Particle physicists have detected six forms of quarks, which combine in different ways to make up protons, neutrons, and other particles.

Closer to the Big Bang, the forces of nature, such as electromagnetism and the forces that hold protons and neutrons together in the nuclei of atoms, evolved in subtle ways. At very early times, they formed a single, unified force, but later they split into separate forces and their relative strengths changed. Perhaps at that time, matter itself formed out of the energy of the Big Bang in a process that scientists don't yet fully understand.

Even with a graviton telescope, astronomers would run into a third barrier at a point when the universe was only 0.0000000000000000000000000000000000000000001 second old and the temperature was a hundred-million-trillion-trillion kelvins. The incredibly high temperatures and densities of this infant universe blocked even gravitons. Scientists have no idea what the universe was like beyond curtain #3 because their best theories (relativity and quantum mechanics) break down at such high temperatures and make ridiculous predictions. For example, the theories predict that light waves at such temperatures would collapse into microscopic black holes.

But even if they succeed, a final curtain may lurk in the depths of time that will prevent a view of the birth of the universe.

Is this curtain really *The End,* or will astronomers eventually overcome this barrier and see what's hidden behind it? They would just need to find some particle that is even more penetrating (and elusive) than neutrinos and gravitons. But according to current theories, no particle is more penetrating than the graviton. If these theories are correct, then curtain #3 really is the final curtain and will keep scientists from ever looking back to the beginning of the universe. Our map of the known universe will then end as abruptly as the edges of the Mappa Mundi. □

Robert Scherrer is an astrophysicist at the Ohio State University in Columbus. Sarah Williams Scherrer is a science writer who has written for Science.

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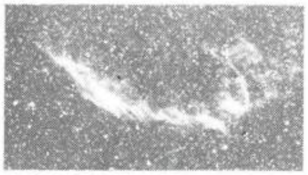

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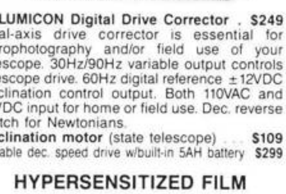

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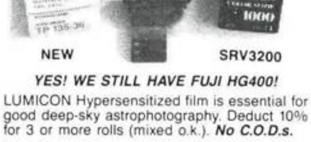

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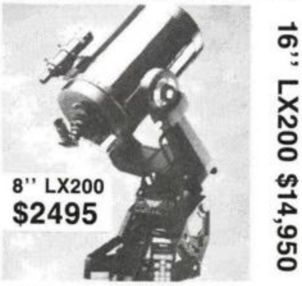

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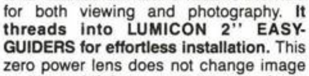
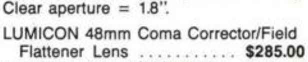


Coma 1 inch off-axis 17½'' f/4.5



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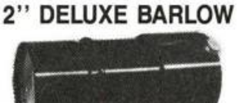

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CIRCLE NO. 52 ON THE READER SERVICE CARD

Was Einstein Wrong?

The Mystery of DI Herculis

When a run-of-the-mill binary star refuses to conform to general relativity, astronomers have to ask: Was Einstein wrong?

by Robert Naeye

Like a modern-day Sherlock Holmes, Villanova University astronomer Edward Guinan is trying to solve a mystery. The fictional supersleuth employed ingenious deduction to unravel the most perplexing of mysteries from the most subtle of clues. In the end, he always got his man. If only Guinan could be so lucky. His case remains unsolved after 18 frustrating years of investigation. "I wish I could find out what the problem is so I can put it aside," he says. "I'm growing older."

The problem is with DI Herculis, a seemingly ordinary 8th-magnitude binary star 2,000 light-years from Earth. DI Her consists of two young blue stars separated by about one-fifth of the Earth-Sun distance. The two stars orbit a common center of mass every 10.55 days. There's nothing particularly unusual about DI Her except for one thing: It appears to be violating Einstein's general theory of relativity.

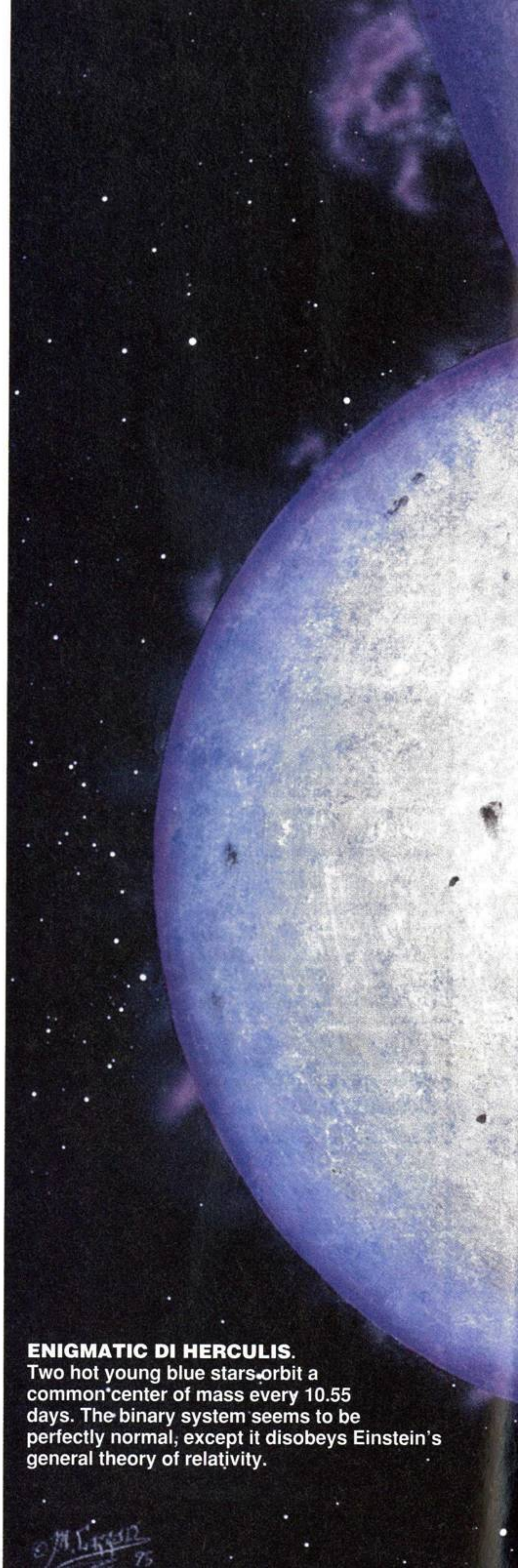
"Just about every astronomer involved in binary star work is aware of this problem," says UCLA astronomer Daniel Popper, a leading authority on binary stars. "The observations are pretty clear. I don't think there's any question there's a discrepancy and, frankly, it is an important one and it's unresolved."

Nobody wants a run-of-the-mill binary to overthrow general relativity, one of the pillars of 20th century physics. The downfall of Einstein's theory would usher physics into a state of crisis. Guinan has spent the better part of the last two decades trying to find another solution to the DI Her mystery. But like a cunning villain, all DI Her has offered him is a trail of false leads.

A 19th Century Enigma

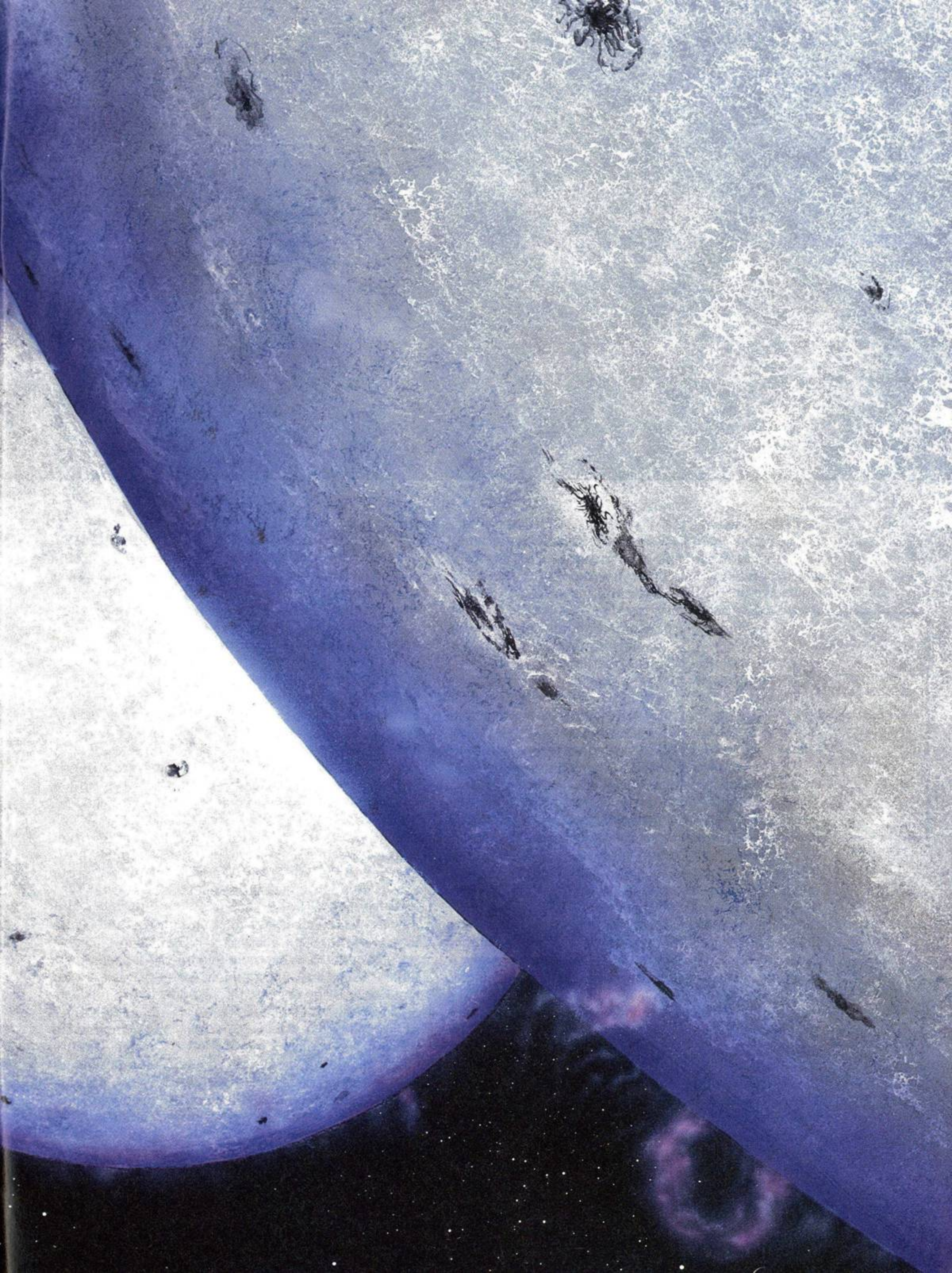
Ironically, DI Her fails a test similar to one of general relativity's initial triumphs. The theory explained a nagging anomaly in the behavior of Mercury's orbit.

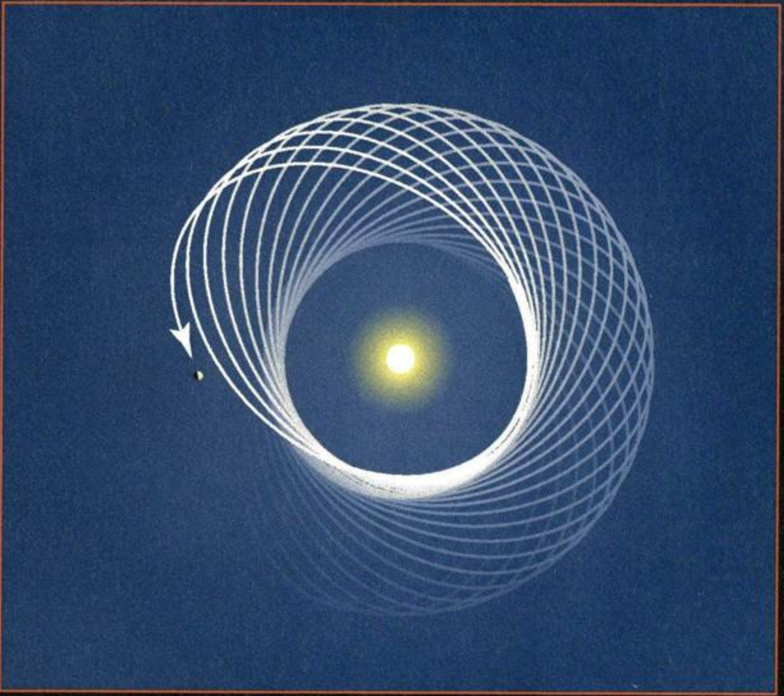
Every planet traces an elliptical path around the Sun. The point where a planet comes closest to the Sun is called perihelion. Each planet's perihelion advances slightly from orbit to orbit because the other planets exert gravitational tugs. This "precession of the



ENIGMATIC DI HERCULIS. Two hot young blue stars orbit a common center of mass every 10.55 days. The binary system seems to be perfectly normal, except it disobeys Einstein's general theory of relativity.

Michael Carroll





ASTRONOMY: Lee Vande Visse

EINSTEIN'S TRIUMPH. Mercury's perihelion – the point closest to the Sun – advances from orbit to orbit. Most of this "precession" was explained by Newtonian physics, but Einstein explained the rest.

perihelion" means a planet's orbit rotates with time, tracing a rosette pattern over the course of many revolutions.

Using Newton's law of gravity, 19th century astronomers calculated that innermost Mercury would have the greatest perihelion precession. But by 1860 it had become painfully obvious that something was wrong. Mercury's perihelion was advancing 574 arcseconds per century, 43 arcseconds faster than Newton's laws predicted. Desperate to save Newton's law, astronomers postulated that a planet interior to Mercury was tugging on its orbit, a planet they named Vulcan. Several observers even claimed to have spotted Vulcan.

> **"I don't think there's any question there's a discrepancy and, frankly, it is an important one and it's unresolved."**
> **— Daniel Popper**

Vulcan turned out to be as illusory as the Martian canals. But Albert Einstein offered a way out of the Mercury problem when he formulated his general theory of relativity in 1915.

Einstein conceptualized the force of gravity in a new way. Newton described gravity as a mutual attraction between two or more bodies. In contrast, general relativity weaves together the dimensions of height, width, and length with a fourth dimension, time — creating a four-dimensional tapestry of space-time. Gravity is not so much a force as a manifestation of the geometry of space-time. Simply put, matter "curves" space-time. In the neighborhood of lightweight bodies like Earth, the difference between Newton's law and general relativity is negligible. But close to a massive body like the Sun, relativity predicts a significant curvature in the geometry of space-time that alters the trajectory of nearby objects like Mercury. Einstein calculated how this effect causes Mercury's perihelion to tumble forward in just the right amount to explain the remaining 43 arcseconds. So far, so good.

DI Herculis Tests General Relativity

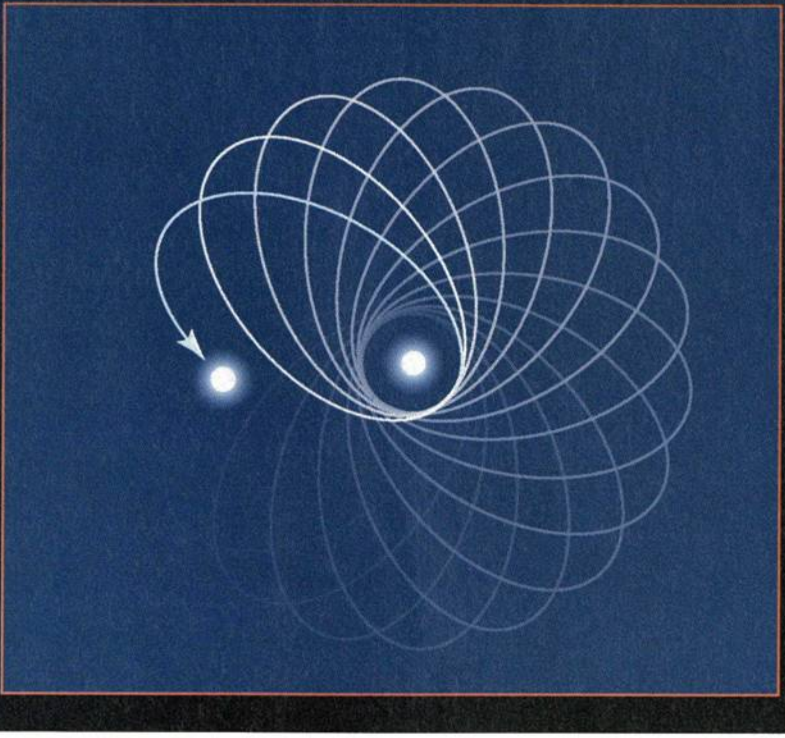
For a scientific theory to be considered valid, it must pass every observational test. General relativity has withstood all challenges within the limits of experimental error. But astronomers have found few situations where they can test the theory in strong gravitational fields, where relativistic effects are the most pronounced.

In 1959, the Danish astronomer Mogens Rudkjøbing pointed out that DI Herculis would provide an excellent test for general relativity in a strong gravitational field. Just as curved space-time causes Mercury's perihelion to advance, curved space-time also causes the longest axis of the elliptical orbit (the line of apsides) to advance. This precession is called apsidal motion. DI Her's stars are massive enough (4.5 and 5.2 solar masses) and close enough that they significantly curve space-time around each other. The curved space-time in DI Her causes the system's line of apsides to advance 200 times faster than the Sun causes Mercury's perihelion to advance.

What makes DI Her such a good test for relativity is that its stars curve space-time around each other, but they are far enough apart so that the gravity from one star doesn't deform the other into an egg-shaped object. DI Her's stars are almost perfect spheres. This is important because any deviation from a sphere magnifies the tidal force, which is an additional Newtonian force, just as the pull of the planets in the solar system adds a significant Newtonian force to Mercury's precession. In almost all close binaries it is very difficult to distinguish the Newtonian effects from relativistic effects. But Rudkjøbing determined that in DI Her, the relativistic effect of curved space-time dominates the Newtonian effect of tidal distortion.

Beginning in 1977, Guinan inadvertently stumbled into his stellar detective role when he began observing DI Her. "I thought this would be a great test of general relativity, and I thought it would work," he recalls. He

DI HERCULIS: THE NON-CONFORMIST. Just as Mercury's perihelion advances, the longest axis in DI Herculis' elliptical orbit advances as well. The observed precession is only one-fourth the amount predicted by theory.



faithfully observes the star every spring and he has checked eclipse records dating back to 1900. But to his chagrin, DI Her is behaving like a petulant child. The apsidal motion should be 4.27 degrees per century. Instead, the observations show that it is only 1.05 degrees per century — less than one-fourth the amount predicted by theory.

No one has found anything wrong with the underlying observations or with Guinan's determination of DI Her's orbital motion. Because the orbital plane is almost perfectly edge-on as seen from Earth, the stars periodically eclipse each other. These eclipses make the calculations virtually foolproof. By measuring the duration of eclipses, how fast the system dims, and the extent to which the luminosity changes, Guinan can precisely determine the stars' sizes, masses, and orbits. He has successfully predicted eclipse timings one year in advance with an error of only 30 seconds. "This stuff is not far-out," he emphasizes. "It's basic astronomy."

To make matters worse, Guinan and his Villanova colleagues Frank Maloney and Patricia Boyd have found a second eclipsing binary, AS Camelopardalis, where general relativity doesn't appear to work either. AS Cam's stars contain 3.3 and 2.5 solar masses, and they are separated by about one-tenth of the Earth-Sun distance. AS Cam's apsidal motion is about one-third of the predicted value. Guinan doesn't dismiss this system, but he emphasizes that the tidal force is considerably larger in AS Cam than in DI Her because AS Cam's stars are closer together.

The Binary Pulsar

Despite DI Her and AS Cam, few reputable astronomers are ready to relegate general relativity to the ash heap of history. Not only has the theory withstood a barrage of experimental tests, it is also an aesthetically beautiful theory that has enjoyed tremendous success predicting counterintuitive phenomena such as gravitational lensing.

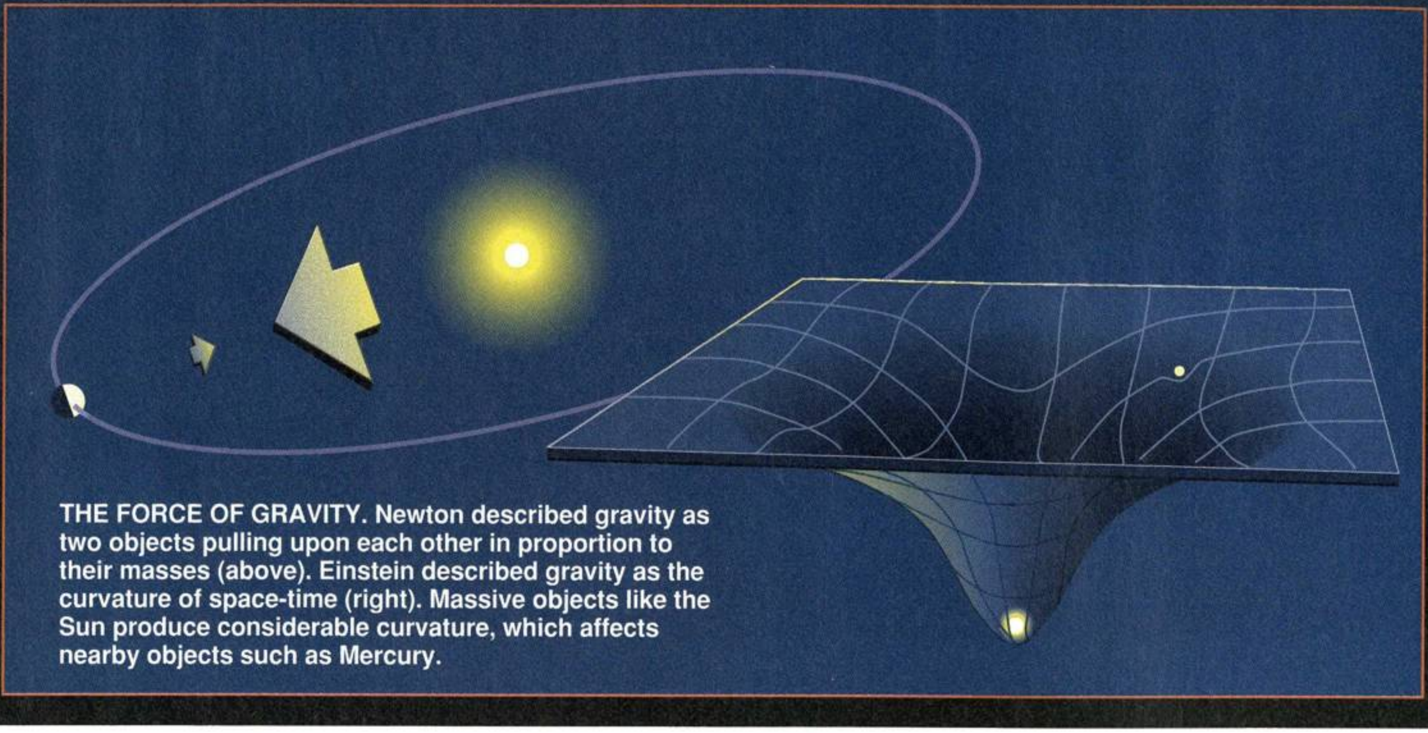
In the 1970s physicist Joseph Taylor (now at Princeton) and graduate student Russell Hulse (now at the Plasma Physics Lab) bolstered relativity after studying a binary pulsar. Taylor and Hulse determined that the binary pulsar's apsidal motion (4.23 degrees per *year* — or 36,000 times the precession of Mercury's perihelion caused by the Sun) fit in beautifully with general relativity.

Over a period of several years Taylor and Hulse observed the two pulsars spiraling closer together. As the pulsars draw closer, they lose orbital energy. According to general relativity, the lost energy is carried away by gravitational waves — subtle ripples in the fabric of space-time that travel at the speed of light. Gravitational waves are so weak that instruments haven't detected them. Taylor and Hulse showed that the observed loss of orbital energy matched relativity's prediction, providing compelling evidence that gravitational waves do in fact exist. Taylor and Hulse garnered the 1993 Nobel Prize for Physics for this research.

The binary pulsar is a particularly good test of relativity. Pulsars are extremely dense and compact — they cram more than a solar mass into a sphere 10 miles across. On the other hand, stars like those in DI Her have extended atmospheres and complicated internal structures. These effects can muddle the apsidal motion.

IT DOESN'T ADD UP

	Predicted precession (per century)	Amount from general relativity	Observed precession
Mercury–Sun	574"	43"	574"
Binary Pulsar	423°	423°	423°
DI Herculis	4.27°	2.34°	1.05°
AS Camelopardalis	44.3°	8.5°	15.0°



THE FORCE OF GRAVITY. Newton described gravity as two objects pulling upon each other in proportion to their masses (above). Einstein described gravity as the curvature of space-time (right). Massive objects like the Sun produce considerable curvature, which affects nearby objects such as Mercury.

For this reason Taylor considers the binary pulsar to be a much stronger test of general relativity than DI Her. "My suspicion is that for reasons none of us have thought of, something else is causing this discrepancy. It would be very hard for me to conclude on the basis of DI Her alone that the place you should be looking for fault is in the understanding of fundamental gravity itself," he says.

If general relativity is not the guilty party, finding the true culprit has turned out to be anything but "elementary." Guinan has investigated all the possible Newtonian explanations that have been proposed, and has virtually eliminated them one by one.

Is There a Hidden Object?

The simplest way to explain the aberrant apsidal motion is to invoke a third body. In the right orbit, such an object's gravity would have a braking effect on the apsidal motion, bringing the theoretical value in line with the observed. But a third body would quickly change the inclination of the binary's orbital plane so it would no longer appear edge-on. Eclipses wouldn't be as dark because the closer star wouldn't completely obstruct the other star. Yet Guinan and his student James Marshall have observed no changes in the eclipse brightness.

> **"A lot of physicists consider general relativity to be a sacred cow. They won't even look at our data. But theories should always be tested."**
> **— Edward Guinan**

There's only one way a third body could affect the apsidal motion without being easily detected. Its orbit would have to be nearly perpendicular to the orbit of the binary. Such an object must orbit at least five times as far away from the binary as Earth is from the Sun or the configuration would be so gravitationally unstable that it would fly apart. At this distance, any object with less than half the mass of the Sun simply would not have enough gravitational pull to cause the discrepancy in the apsidal motion. But Guinan and Marshall would have detected the light from a star with more than a solar mass. Only a narrow range of stars in a narrow range of orbits can do the trick.

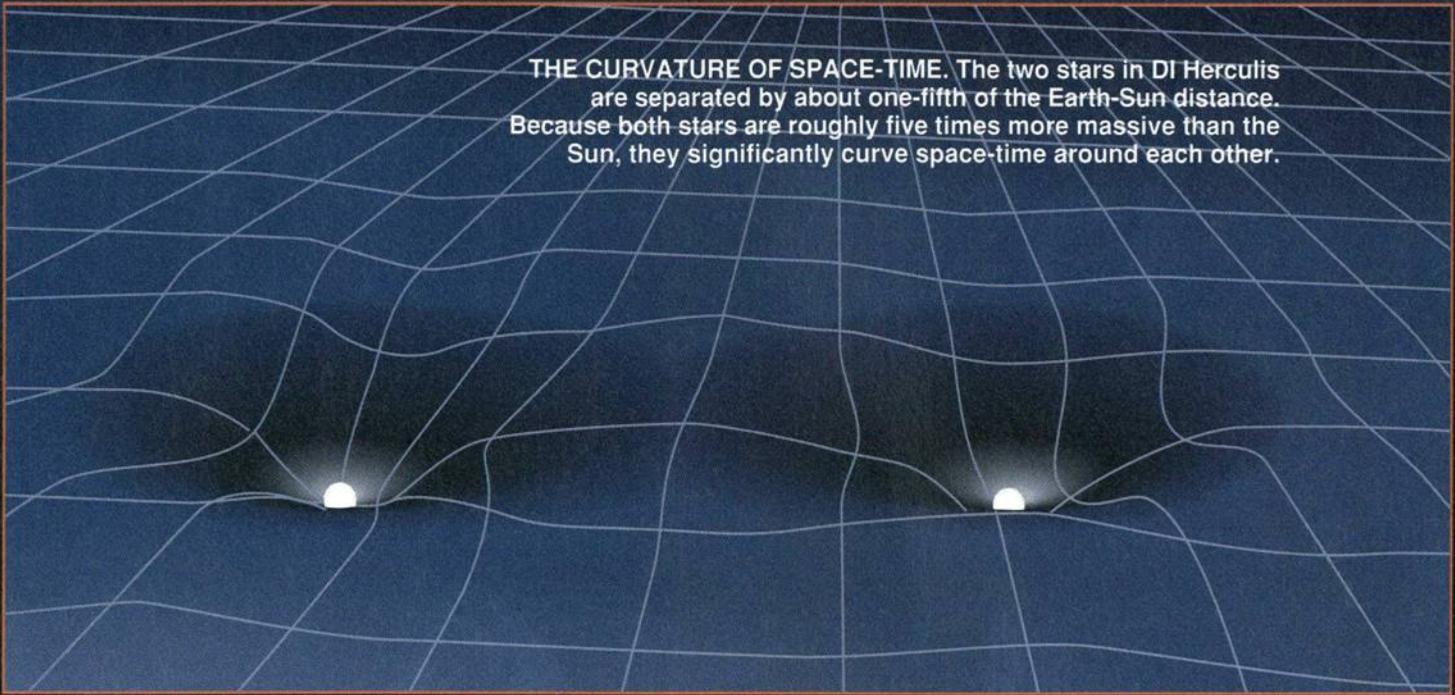
If the third body is a massive dark object such as a black hole or pulsar, the gaseous winds from DI Her's two stars would ram into it. The object's immense gravity would funnel the gas into a rapidly whirling disk. The gas would heat up and emit X rays. Guinan has checked the X-ray satellite catalogs; there are no X-ray sources in DI Her's vicinity. "I don't know what else to do," he says. "A third body would have to be hidden so well that it's just in the right place and moving in just the right direction to cause this to happen and yet not be seen. This is *highly* unlikely."

The Mystery Deepens

Guinan and Maloney next examined the possibility that the rotational axes of the two stars are tipped so they are nearly parallel to the orbital plane. In such an alignment centrifugal forces would create rotational bulges at the stars' equators, and the gravity from these bulges would pull back on the apsidal motion.

But Guinan and Maloney could tell if the stars' rotational axes were tipped. Think of a nickel spinning on its edge. As you eyeball the nickel, one edge is approaching you, and the other is receding. The same thing happens in a spinning star with the same orientation. This causes the light from the side spinning toward Earth to be scrunched, shifting the spectrum toward the blue. The receding side's light is stretched, so the spectrum shifts toward the red.

As an eclipse begins, the closer star obstructs the more distant star's blueshifted side. When the eclipse is ending, the front star obstructs the redshifted side. In both DI Her stars Guinan and Maloney have observed the alternate disappearance of blueshifted and red-



THE CURVATURE OF SPACE-TIME. The two stars in DI Herculis are separated by about one-fifth of the Earth-Sun distance. Because both stars are roughly five times more massive than the Sun, they significantly curve space-time around each other.

shifted light, meaning the stars' spin axes must be almost perfectly perpendicular to the orbital plane.

As Joseph Taylor suggested, perhaps the internal structure of DI Her's stars is messy. This would produce an additional twisting force on the apsidal motion. But Guinan has modeled various stellar interiors on a computer. Changing the distribution of mass doesn't work. "The only way to explain it with internal structure would be for the density to decrease as you go deeper into the star, which is physically impossible," he says.

Guinan has also investigated and ruled out the possibility that extended stellar atmospheres, unusual magnetic fields, or extreme stellar winds are causing the discrepancy. No abnormalities have ever turned up in his observations besides the aberrant apsidal motion. The list of suspects is diminishing, other than the unthinkable — that general relativity has a problem.

Was Einstein Wrong?

Despite his inability to find a solution, Guinan can't quite bring himself to accept the old Holmesian adage, "When you have eliminated the impossible, whatever remains, however improbable, must be the truth." "There's a slight chance there's something wrong with general relativity when it applies to massive stars," says Guinan. "On the other hand, a lot of physicists consider general relativity to be a sacred cow. They won't even look at our data. But theories should always be tested."

MIT physicist Sean Carroll, who has worked with Guinan on DI Her, has tried without success to modify general relativity so it is consistent with DI Her and the many situations in which general relativity works. "You can never say such a law is impossible because there's always some theory that you didn't think of yet that explains everything," he says.

The one theory that claims to explain DI Her and falls in line with all of relativity's successful predictions is the brainchild of University of Toronto physicist John Moffat. Moffat first published his theory in 1979. The theory is a slightly modified version of general relativity. It differs from Einstein's theory in only a few special circumstances, just as relativity diverges from Newton's law only in the presence of extremely massive bodies.

In Moffat's theory, different kinds of matter curve space-time by different amounts. But the theory requires that DI Her's stars be filled with exotic, as-yet undiscovered subatomic particles. "This is sort of like invoking the tooth fairy twice," notes Carroll. "You need both a new theory of gravity and you need undiscovered particles collecting in these stars. When you pile speculative hypotheses on top of one another, it becomes less compelling."

Another possibility is that space-time has higher dimensions. General relativity works in four dimensions. But extending the theory to five or more dimensions might explain the discrepancy in DI Her.

With virtually no one prepared to abandon general relativity, and with no resolution in sight, DI Her continues to frustrate Guinan and consume portions of his precious research time. "I like mysteries, but this one has gone on far too long for me," he says. "I would love to find something wrong with these binaries. It's something that might be unique to DI Her and AS Cam, something in their histories, something in their evolution, something that makes them different from normal binary stars. I'm usually a pretty good stellar detective, but these stars have thrown me." □

NO SOLUTION IN SIGHT

Possible Cause	Why Ruled Out
Third body	No evidence for orbital perturbation
Tipped rotation axes	Spectra show upright orientation
Messy internal structure	Computer models, other binaries OK
Stellar atmospheres	No anomalies in visible or ultraviolet
Unusual magnetic fields	No magnetic fields detected
Extreme stellar winds	Winds observed to be weak

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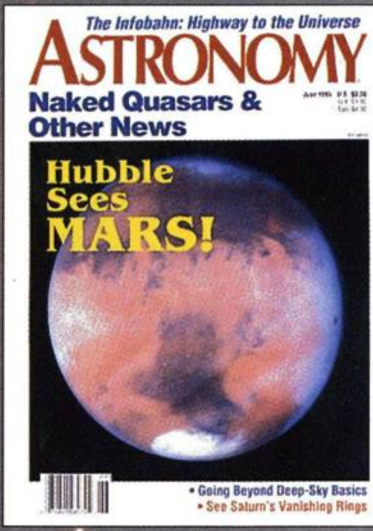

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SKY ALMANAC

Highlights
by Alister Ling

Date	Event
2	The Moon Meets a Ringless Saturn. . . . . . . *(p. 70)*
17	Spot the Swift Leonids. . . . . . *(p. 62)*
29	Sniff Out Iris . . *(p. 68)*

All month:

First Views:
The Andromeda Galaxy. . . . . . . *(p. 67)*
The Demon Star Winks . . . . *(p. 68)*
Evening Planets Huddle . . . . . . *(p. 70)*
Observer's Challenge:
NGC 1275 and its Galaxy Cluster. *(p. 71)*

The Starry Sky:
Andromeda. . . *(p. 69)*

The Andromeda Galaxy beckons from two million light-years away, while closer to home, the solar system struts its stuff in the west after sunset, offering up three planets and an asteroid.

by Deborah Byrd

Three bright planets, **Mars**, **Venus**, and **Jupiter**, put on a spectacular show this month for those who look in the evening twilight sky. The three planets are easily seen low in the west, shortly after sunset, strung out along the southwestern horizon. Venus is the lowest, Jupiter is the highest, and Mars appears in the middle.

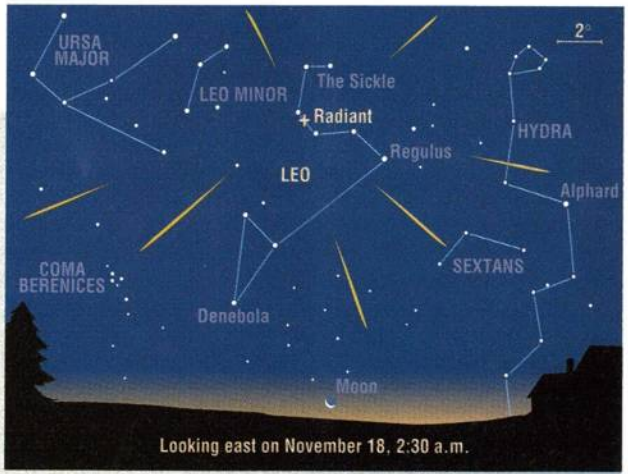
Even when they are low in the sky, Venus and Jupiter outshine every other object in the heavens, save the Sun and Moon. Venus is the brighter of the two, at magnitude –3.9, while Jupiter shines at magnitude –1.8. Mars is not nearly as brilliant as the other two planets because it is about as far from Earth as it can be, nearly 19 light-minutes away. In the twilight sky, it appears remote and faint, at magnitude 1.3. Only the company it keeps this month, and its reddish color, cause Mars to be noticeable at all.

One conspicuous star begins the month nestled among the evening planets. Antares, the brightest star in the constellation Scorpius, lies closest to Mars in early November, when the star and planet are within 4° of each other from November 1 through 4. At magnitude 1.0, Antares is brighter than the Red Planet, and at 330 light-years away, it is also vastly more distant.

The name Antares means "rival of Ares," with Ares being the Roman name for the war god Mars. It doesn't take a keen eye to see that brighter Antares does indeed outshine its dusky rival in the November evening twilight. Like competitive siblings, the two even seem to mimic one another by giving off the same reddish light. Antares, however, appears red because it is a relatively cool star, while the red color of Mars comes from fine reddish dust on the surface of the desert planet. As the month passes, Mars gets the last word by remaining visible, while its rival sinks into the sunset glare.

After Antares disappears, the focus turns completely planetary. From about November 17 until

Spot the Swift Leonids



Looking east on November 18, 2:30 a.m.

Late autumn's Leonids are one of history's most interesting showers because of its tendency to storm every 33 years. The last major storm happened in 1966, when meteors fell at a rate of 40 per second! Astronomers anticipate the next major outburst in 1999, and in the meantime are keeping their eyes skyward if activity picks up between now and then.

The Leonids peak this year on Friday night, November 17/18, at 3 a.m. EST. Although light from a waning crescent Moon might interfere during the early morning hours, you will still see a number of bright meteors, some leaving long trails after they enter Earth's atmosphere.

Leonids get their name because they appear to radiate from the sickle of Leo, which rises in the east near midnight. Many are bright and appear as piercing green or blue light streaks coming from the mane of Leo the Lion. If you want to see long trails, look straight up and enjoy the winter Milky Way while you wait. From a dark site before moonrise you will see about ten an hour. Don't forget binoculars so you can closely examine any glowing trails left by bright meteors. — *Alister Ling*

Rick Schmidt

NOVEMBER

2 Mars passes 4° north of Antares, 7 a.m. EST
The Moon passes 6° north of Saturn, 9 p.m. EST (page 70)

7 Full Moon is at 2:20 a.m. EST

10 Venus passes 4° north of Antares, 1 p.m. EST

11 The Moon is at apogee (251,985 miles from Earth), 4 p.m. EST

15 Last Quarter Moon is at 6:40 a.m. EST

16 Mars passes 1.2° south of Jupiter, 3 a.m. EST

19 Venus passes 1.3° south of Jupiter, 7 a.m. EST

22 Saturn is stationary, 9 a.m. EST

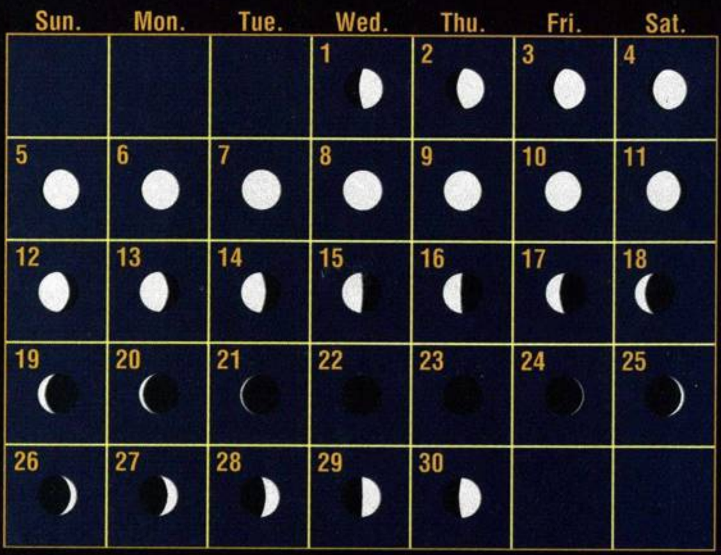
22 New Moon is at 10:43 a.m. EST
Venus passes 0.2° south of Mars, 5 p.m. EST

23 Mercury is in superior conjunction, midnight EST
Pluto is in conjunction with the Sun, 2 a.m., EST
The Moon is at perigee (223,488 miles from Earth), 11:01 p.m. EST
The Moon passes 4° north of Jupiter, 8 p.m. EST (page 70)

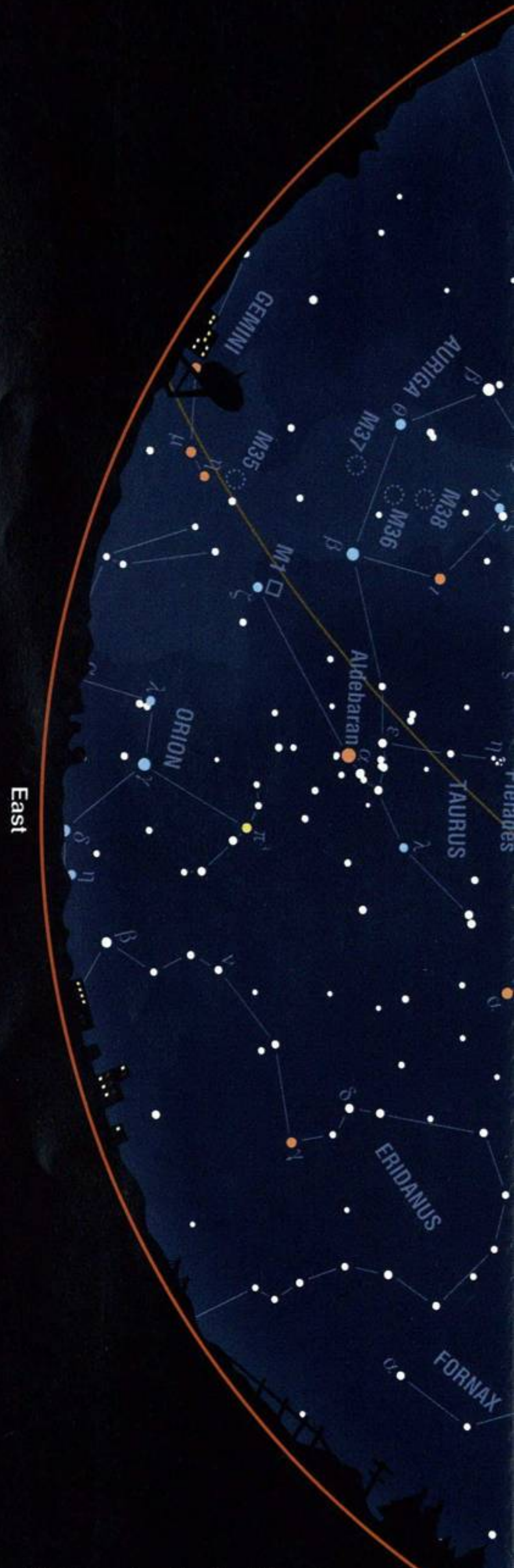
24 The Moon passes 5° north of Mars, 3 a.m. EST
The Moon passes 6° north of Venus, 4 a.m., EST

25 First Quarter Moon is at 1:28 a.m. EST

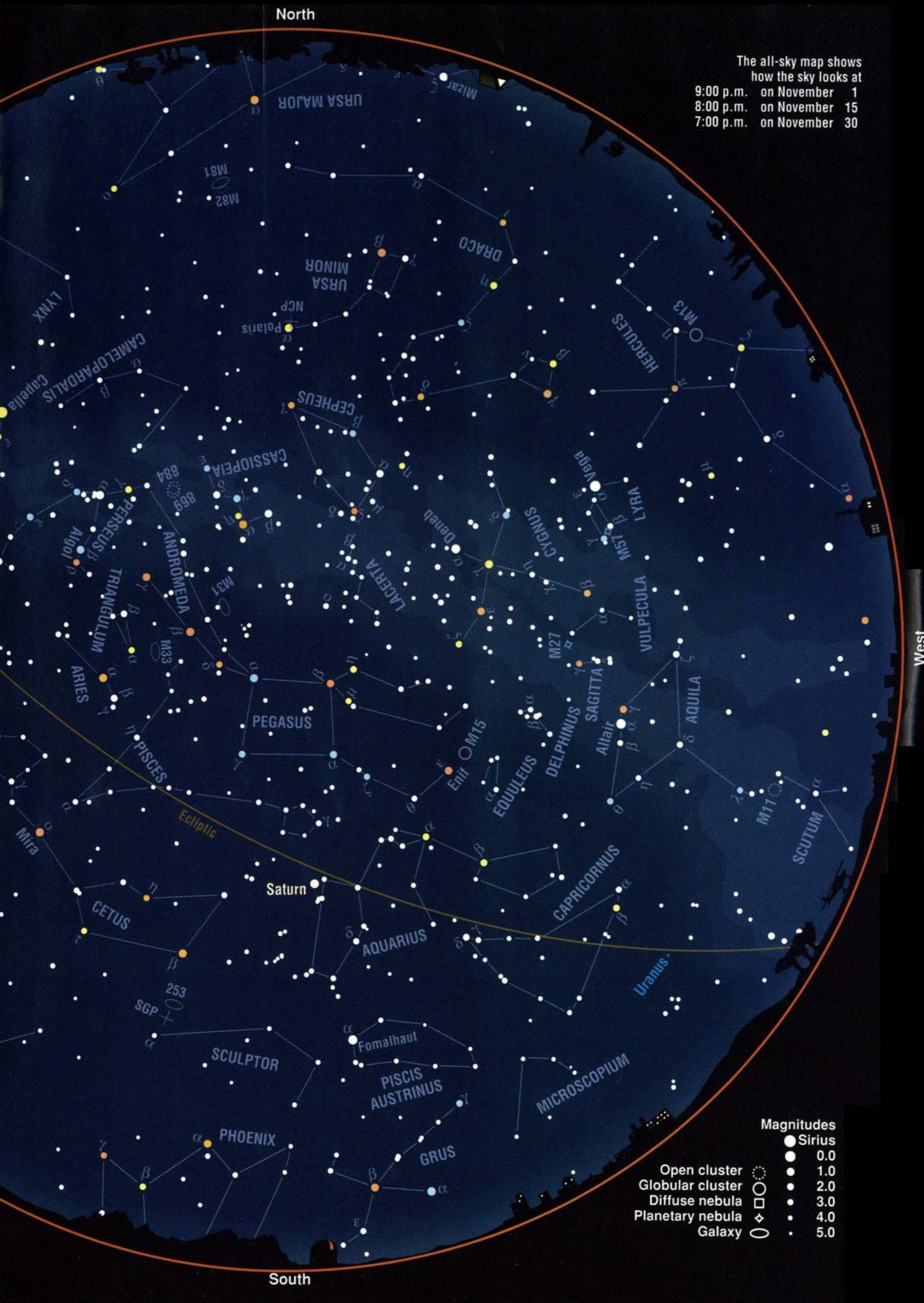
30 The Moon passes 6° north of Saturn, 2 a.m. EST



Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

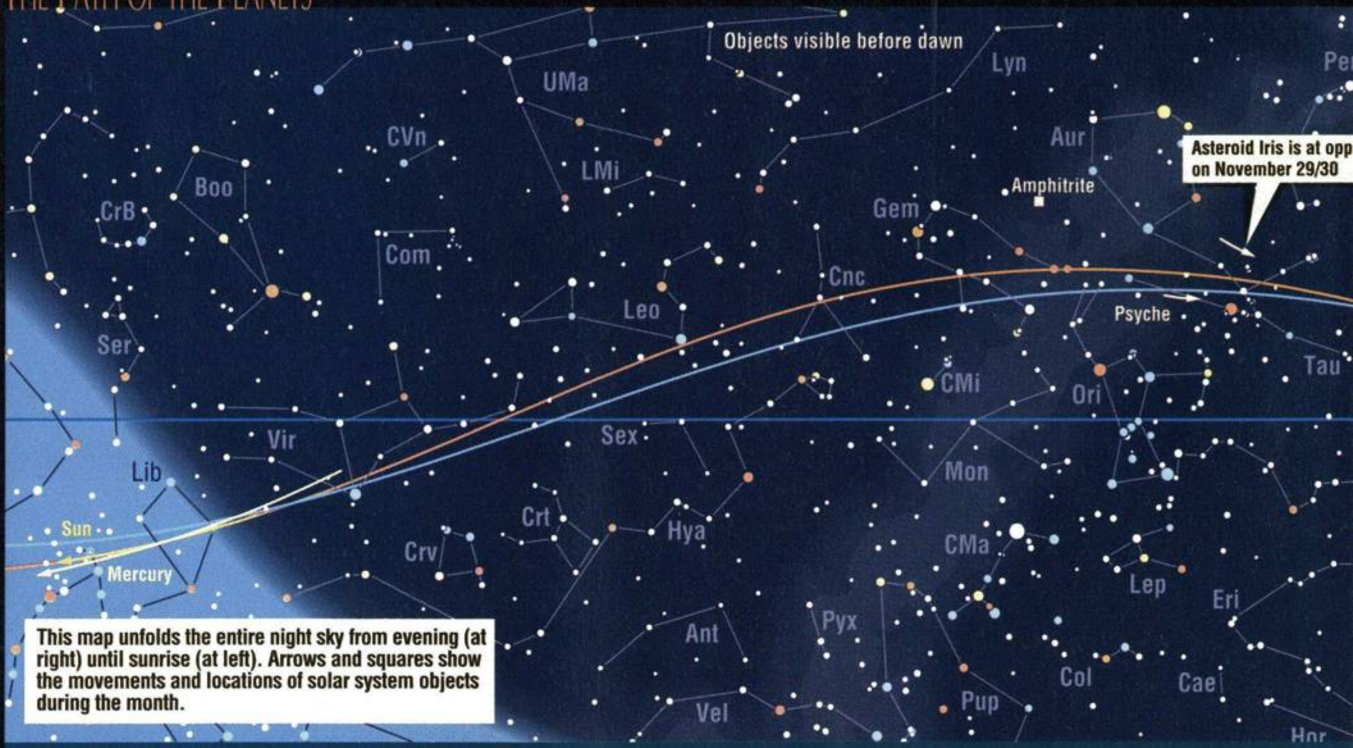


This map portrays the sky at times shown in the upper right corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above your horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.


North
West
South
URSA MAJOR
Mizar
M81
M82
DRACO
URSA MINOR
NCP
Polaris
LYNX
CAMELOPARDALIS
Capella
CEPHEUS
HERCULES
M13
CASSIOPEIA
884
869
PERSEUS
Algol
Vega
LYRA
M57
Deneb
CYGNUS
LACERTA
ANDROMEDA
M31
TRIANGULUM
M33
VULPECULA
M27
SAGITTA
ARIES
PEGASUS
M15
DELPHINUS
Altair
AQUILA
PISCES
Enif
EQUULEUS
M11
SCUTUM
Mira
Ecliptic
CAPRICORNUS
Saturn
CETUS
AQUARIUS
Uranus
253
SGP
SCULPTOR
Fomalhaut
PISCIS AUSTRINUS
MICROSCOPIUM
PHOENIX
GRUS
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

The all-sky map shows
how the sky looks at
9:00 p.m. on November 1
8:00 p.m. on November 15
7:00 p.m. on November 30

THE PATH OF THE PLANETS


Objects visible before dawn
Lyn
Pe
UMa
CVn
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LMi
Boo
CrB
Amphitrite
Gem
Com
Cnc
Leo
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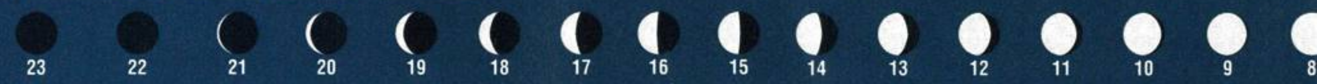
Ser
CMi
Tau
Ori
Vir
Sex
Lib
Mon
Crt
Hya
Sun
Crv
CMa
Mercury
Lep
Eri
Ant
Pyx
Col
Cae
Vel
Pup
Hor

Asteroid Iris is at opp
on November 29/30

This map unfolds the entire night sky from evening (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system objects during the month.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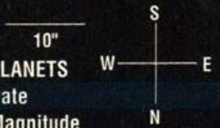
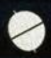
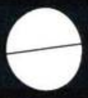
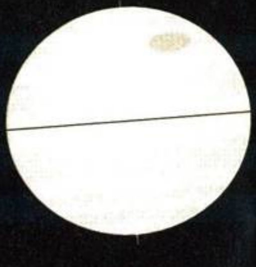
To locate the Moon in the sky, draw a line from the phase shown for the day straight up to the curved light-blue line.



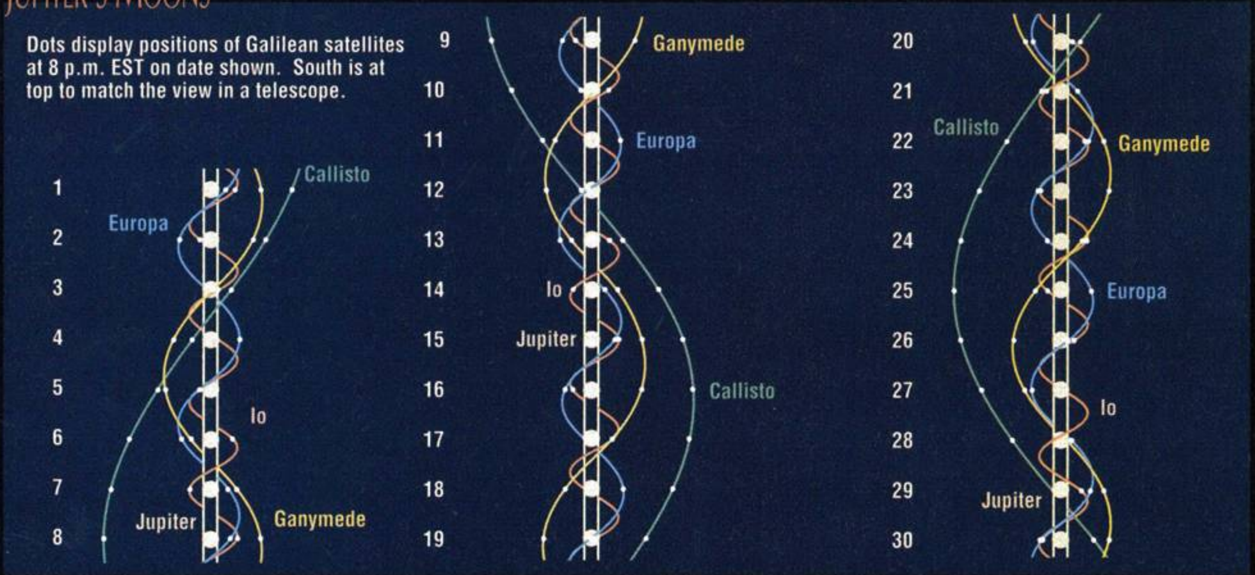




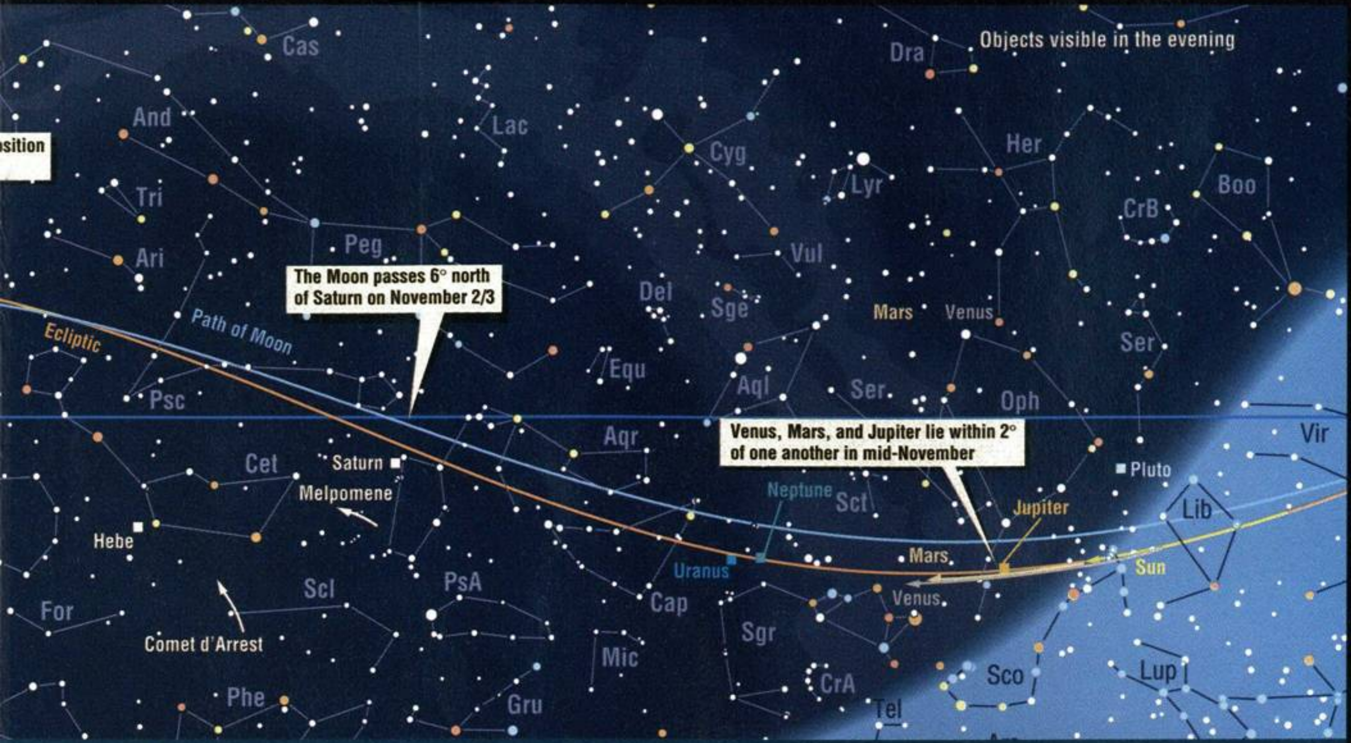


PLANETS	MERCURY	VENUS	MARS	JUPITER	SA
Date	November 1	November 15	November 15	November 15	Nove
Magnitude	–0.9	–3.9	1.3	–1.8	
Angular Size	5.4"	10.8"	4.1"	32.1"	1
Illumination	88%	93%	98%	100%	1
Distance (AU) from Earth	1.247	1.539	2.263	6.150	8
Distance (AU) from Sun	0.367	0.728	1.443	5.286	9
Right Ascension (2000.0)	13h33.9m	16h52.1m	17h09.1m	17h12.2m	23h
Declination (2000.0)	–7°49'	–23°18'	–23°47'	–22°40'	–

JUPITER'S MOONS



Dots display positions of Galilean satellites at 8 p.m. EST on date shown. South is at top to match the view in a telescope.


Cas
Dra
Objects visible in the evening
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Her
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Tri
CrB
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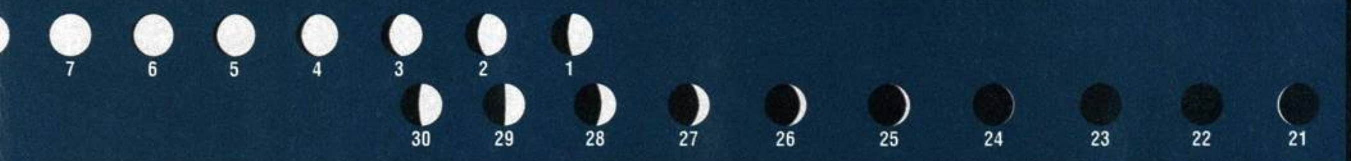
Sge
Mars
Venus
Path of Moon
Ecliptic
Ser
Equ
Psc
Aql
Ser
Oph
Aqr
Vir
Cet
Saturn
Pluto
Melpomene
Neptune
Scl
Lib
Jupiter
Hebe
Uranus
Mars
Sun
Scl
PsA
Cap
Venus
For
Sgr
Comet d'Arrest
Mic
CrA
Sco
Lup
Phe
Gru
Tel

The Moon passes 6° north of Saturn on November 2/3

Venus, Mars, and Jupiter lie within 2° of one another in mid-November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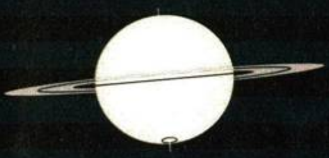
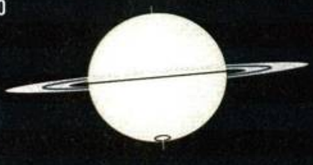
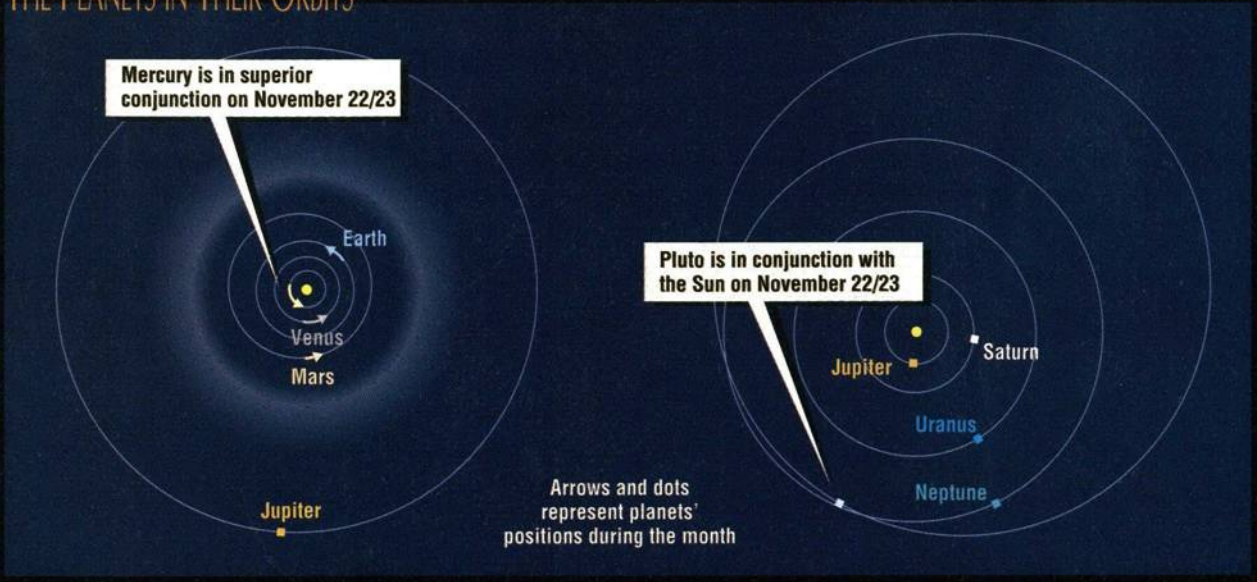




TURN	SATURN	URANUS	NEPTUNE	PLUTO
mber 1	November 30	November 15	November 15	November 15
.9	1.0	5.8	8.0	13.8
.6"	17.8"	3.5"	2.2"	0.1"
0%	100%	100%	100%	100%
924	9.354	20.136	30.632	30.822
595	9.587	19.739	30.166	29.868
21.0m	23h19.7m	19h57.6m	19h40.2m	16h03.0m
42'	–6°44'	–21°15'	–20°56'	–7°38'

THE PLANETS IN THEIR ORBITS


Earth
Venus
Mars
Jupiter
Saturn
Jupiter
Uranus
Neptune

Mercury is in superior conjunction on November 22/23

Pluto is in conjunction with the Sun on November 22/23

Arrows and dots represent planets' positions during the month

November 23, the trio of evening planets are spectacularly close to one another. For six days, Venus, Mars, and Jupiter line up in front of the constellation Ophiuchus, while the Moon slides into the scene during evening twilight on November 23. Don't miss this great planetary conjunction of 1995! (See "A Stunning Planetary Trio," page 78.)

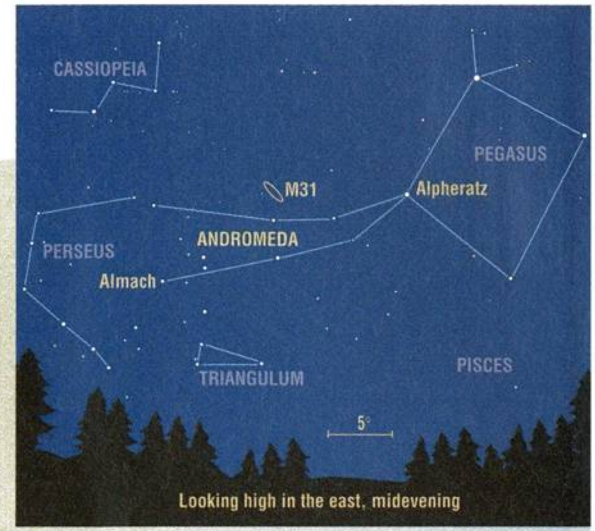
When planets group together like this, people often ask how special an event this is. Sensationalistic books link planetary alignments to earthquakes and other Earthly phenomena. But the idea of cause-and-effect here makes astronomers smile, or cringe. In order to see planets bunched together in our sky, they must merely line up along our line-of-sight, as seen from Earth. In reality, they are in vastly different parts of space.

The truth is that the ceaseless movement of worlds creates endless configurations, many of which qualify as "lines in space" at one time or another. Most lines are never as straight as people imagine. What's more, these arrangements are not rare at all, but instead are part of what the night sky has to offer. And in November 1995, it's Jupiter, Mars, and Venus that lie along the same line of sight. The last time they were grouped in this way was June 1991.

Planets aren't the only objects that "line up" or have conjunctions in the night sky. When an astronomical reference book says that Mars is 4° north of Antares on November 2 at 12h UT (universal time), it means at that moment Mars has the same right ascension as Antares. (Right ascension is analogous to longitude on Earth's globe.) So Mars will be closest to Antares in right ascension on November 2 at 12h UT.

In reality, two objects might apppear slightly closer before or after this right ascension conjunction. With that in mind, it certainly is worth keeping an eye on the sky several days before or

First Views:
The Andromeda Galaxy



On a clear night, you can see 2.2 million light-years toward a nearby island universe. This stellar metropolis is the great Andromeda Galaxy, a mighty assemblage of a few hundred billion stars in the form of a spiral galaxy like our own. Even though the Andromeda Galaxy is 1/3 larger than our Milky Way, its vast distance reduces it to a soft naked eye-glow in our sky.

This glow of light was just one of many patches of light until 1924, when Edwin Hubble made the remarkable announcement that it was not a nearby cloud of gas, but a distant galaxy, or as his contemporaries put it, "an island universe."

Oddly enough its naked-eye majesty escaped the attention of the ancient Greeks; the first recorded mention of the Andromeda Galaxy was by the Persian astronomer Al-Sufi in 964 AD. Today we call it M31, number 31 on a list of irritating comet-lookalikes gathered by professional comet-hunter Charles Messier in the 18th century.

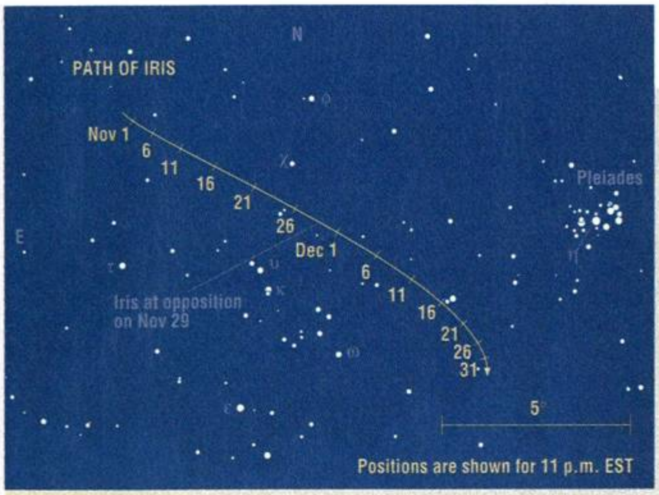
Finding M31 is easy, since it is high in the east and almost overhead after sunset. Use Gamma (γ) Andromedae, also known as Almach, and Alpheratz (Alpha (α) Andromedae), the star that marks the northeast corner of the Great Square in Pegasus, as your markers. Move about half way from Alpheratz to Almach and then north about 5°. There you'll find M31.

Under reasonably dark skies M31 looks like a gray, oval patch of light to the naked eye. From a typical city backyard you'll need binoculars to spot its small hazy glow. A scope shows a little more, including satellite galaxies M32 on the galaxy's east edge and NGC 205 to the west.

Out in the country, obscuring dust lanes that define the galaxy's spiral shape become visible in simple binoculars. With a little patience you may also note that the northwest side is sharp-edged compared to the southeast, where the glow slowly fades into the background sky. — *A. L.*

Alan Dyer

Sniff Out Iris


N
PATH OF IRIS
Nov 1
6
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16
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Dec 1
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Pleiades
E
Iris at opposition on Nov 29
5°
Positions are shown for 11 p.m. EST

Asteroid 7 Iris passes between two beautiful naked-eye open clusters in Taurus, the Hyades and the Pleiades, during the months of November and December. What better way to find this minor planet than to hop to its location from the Pleiades using binoculars? Since the asteroid is 210 km across, it gets reasonably bright — up to magnitude 6.8 — when it reaches opposition the night of November 29.

Use the field chart above to follow its path through western Taurus as the weeks progress. The surest method of confirming an asteroid sighting is to do a sketch of the field and then come back a few hours later or the next night to see which "star" moved. Anything that has moved reveals itself as the interloper. I've followed more than 20 asteroids using these charts in the last three years, so why don't you follow me and keep track of your catches?

Check Iris out on the night of November 26-27, when it passes within a mere 30" of the 7th-magnitude star 62 Tauri. You will need a telescope to separate them at their closest. — *A. L.*

ASTEROID IRIS COORDINATES

Date	R.A. (2000)	Dec.	Mag.
Nov. 1	4h41.1m	26°48'	7.6
Nov. 6	4h38.8m	26°27'	7.5
Nov. 11	4h35.5m	26°02'	7.3
Nov. 16	4h31.6m	25°33'	7.2
Nov. 21	4h27.1m	25°00'	7.0
Nov. 26	4h22.3m	24°24'	6.8
Dec. 1	4h17.6m	23°47'	6.8
Dec. 6	4h13.0m	23°08'	7.0
Dec. 11	4h09.0m	22°31'	7.2
Dec. 16	4h05.6m	21°55'	7.4
Dec. 21	4h02.9m	21°22'	7.6
Dec. 26	4h01.2m	20°53'	7.8
Dec. 31	4h00.5m	20°28'	7.9

Positions are shown for 11 p.m. EST (10 p.m. CST, 9 p.m. MST, and 8 p.m. PST)

The Demon Star Winks

For ages, a mysterious star in Perseus has waxed and waned in brightness. Its Arabic name "Algol" means "Demon's Head," which suggests that the Arabs may have been the first to discover its intriguing variations. After Western observers finally noticed the star's variability in 1667, an incredible 100 years passed before John Goodricke actually pinned down Algol's period.

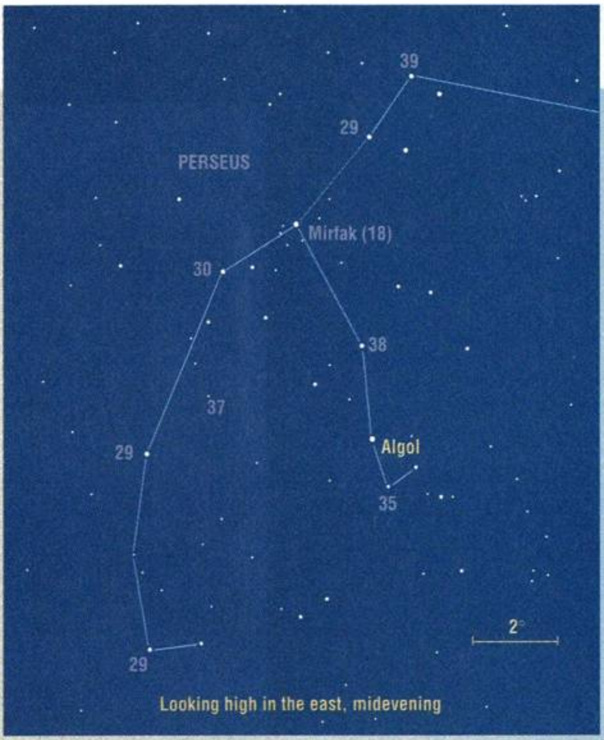
Algol is an eclipsing binary. Two stars orbit close together, and when the fainter one passes in front of the brighter one, the total light output drops. Every 2.9 days, or 69 hours, for five hours it drops from magnitude 2.1 to 3.4 and then slowing climbs back to full brightness over the next five hours. If minimum falls at around 1 a.m., watch Algol fade by more than a whole magnitude from the beginning of the evening.

Consult the table to find when Algol is in deepest eclipse and then compare its brightness with neighboring stars every 15 minutes. To help you do this, the accompanying map of Perseus has stars labeled to 1/10th of a magnitude, with the decimal points removed (e.g., 35 = magnitude 3.5).

Will you get caught in the spell of Algol? — *A. L.*

ALGOL AT MINIMUM BRIGHTNESS

Date	Time (EST)
Nov. 1	1:35 a.m.
Nov. 3	10:24 p.m.
Nov. 6	7:13 p.m.
Nov. 9	4:02 p.m.
Nov. 12	12:51 p.m.
Nov. 15	9:40 a.m.
Nov. 18	6:28 a.m.
Nov. 21	3:17 a.m.
Nov. 24	12:06 a.m.
Nov. 26	8:55 p.m.
Nov. 29	5:44 p.m.

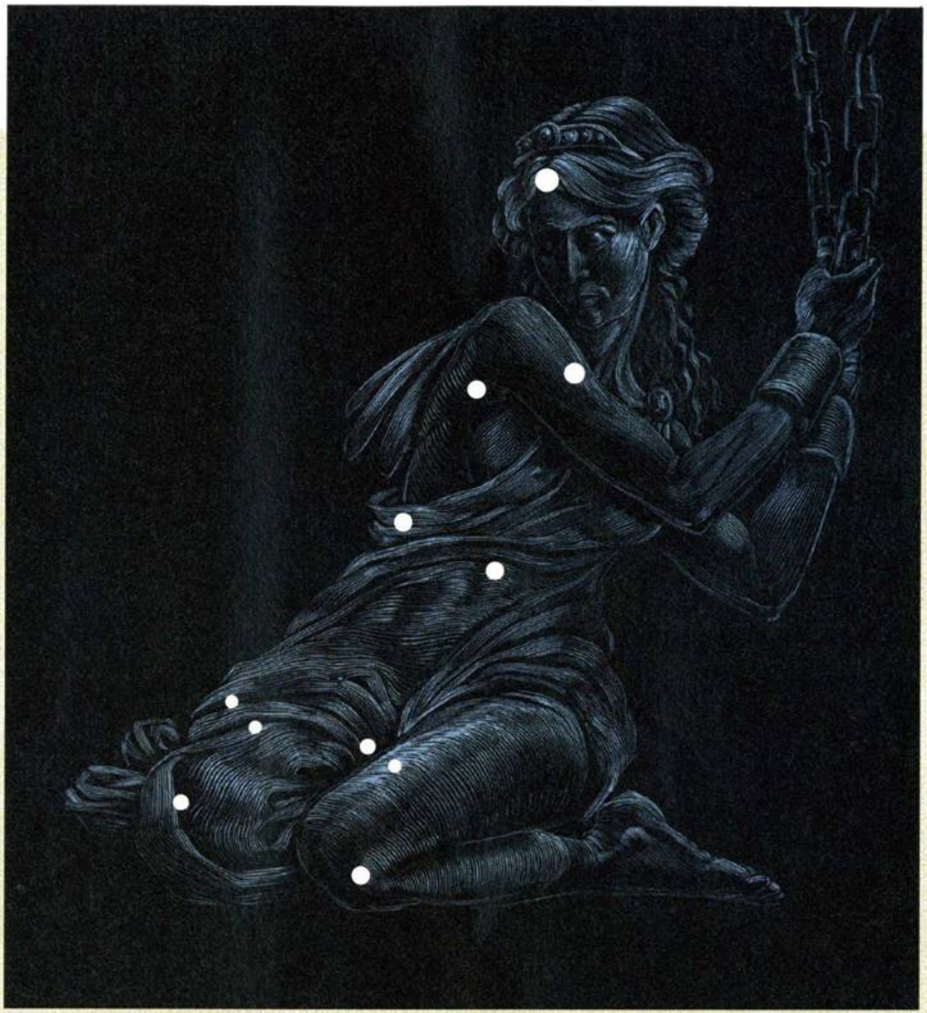


after a designated conjunction day and hour.

A conjunction between Mars and Antares isn't the only one happening this month. Venus lies 4° north of Antares on November 10; Mars is 1.2° south of Jupiter on November 16; Venus is 1.3° south of Jupiter on November 19; Venus lies 0.2° south of Mars on November 22; Jupiter shines 4° south of the Moon on November 24; Mars is 5° south of the Moon on November 24; and Venus is found 6° south of the Moon on November 24. No one can say November isn't the month for conjunction-lovers!

With all these celestial comings and goings, don't forget to turn your binoculars or telescope on the evening planets. Venus, Jupiter, and Mars are in the same field of view in binoculars for several days around November 20. Through a telescope, Venus sports an 11"-diameter fea-

The Starry Sky: **Andromeda**



Keith Ward

The richest story in skylore focuses on an autumn constellation visible this month in the Northern Hemisphere. This is the myth of Andromeda, the hapless Princess of Ethiopia and daughter of King Cepheus and Queen Cassiopeia.

When Cassiopeia boasted that her own beauty and that of Andromeda's was greater than that of the sea nymphs, the god of the sea Poseidon sent the mighty whale Cetus to destroy Ethiopia's coast. The only way to appease the monster was to sacrifice lovely Andromeda. After much agony on the part of her parents, she was chained to a rock by the sea.

Luckily, just then, a great hero rode by on his winged horse. This was Perseus, riding Pegasus. After taking advantage of the opportunity to demand Andromeda's hand in marriage and a kingdom of his own, Perseus slayed the monster and saved the princess. He and Andromeda went on to live a long and happy life together. The gods were said to be so pleased that they granted the main characters of this drama a place among the stars.

Just as the Princess Andromeda is chained to a rock in ancient mythology, so the constellation Andromeda is chained to a neighboring star pattern. In the sky, you can see that the star Alpheratz, Alpha (α) Andromedae, also marks the northeastern corner of the Great Square of Pegasus. Andromeda shared this star with Pegasus until the International Astronomical Union decreed earlier in this century that Alpheratz belonged to Andromeda alone.

The rest of Andromeda extends to the northeast from Alpheratz in two graceful, diverging lines of stars. The more southerly line appears brighter due to the presence of the stars Almach and Mirach, both of which shine at about second magnitude. A small telescope reveals Almach to be a double star with components of yellow and blue-white. The more northerly line of stars in Andromeda is more difficult to see. It contains stars shining at about fourth or fifth magnitude.

Andromeda's faintest stars are obvious to the naked eye when viewed from a dark, moonless country sky. Besides a delicate scattering of stars, Andromeda contains one of the greatest treasures the sky has to offer any observer, a sight that cannot fail to expand your reach.

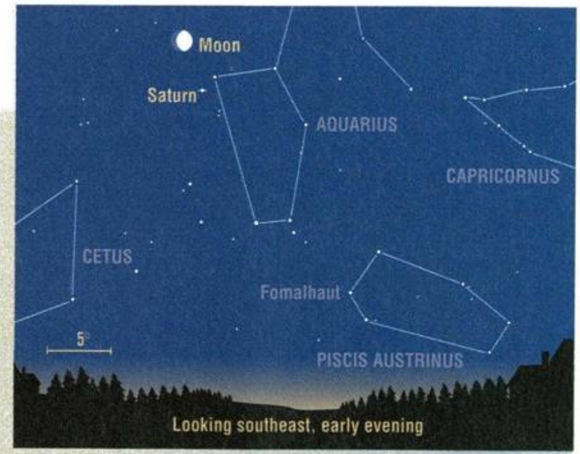
In a terrestrial desert, your horizon is perhaps a dozen miles away. From a mountaintop you may see about a hundred miles. When you gaze at the Moon, you are looking a quarter of a million miles away. A typical star visible in the night sky may be tens or hundreds of light-years away, with each light-year equaling about six trillion miles. But the most distant object easily visible to the naked eye is within Andromeda's boundaries. This is the Andromeda Galaxy, which appears under a dark sky as a faint patch larger than the Full Moon (see First Views, page 67). A century ago, astronomers believed this object was a single star in the process of forming its own solar system. Now they known it is a separate galaxy, an "island universe" containing hundreds of billions of stars, located more than two million light-years away. — *Deborah Byrd* tureless disk, and Mars shows an equally featureless, even smaller 4"-diameter disk. Jupiter, as always, looks much larger through a telescope. This month, the giant planet's equatorial diameter measures 32". A telescope is of less use this month for glancing planetary detail because the planets are so low in the sky. Don't be dismayed if they appear to swim through your eyepiece behind the great thickness of Earth's atmosphere.

Uranus and **Neptune** are higher in the west after sunset. Both begin the month in front of the constellation Sagittarius, but Uranus crosses the boundary into Capricornus before the month's end. Where Uranus shines at the limit for naked-eye visibility, at magnitude 5.8, Neptune requires optical aid to be seen at magnitude 8.0. This month these two gas-giant worlds, whose names we've gotten used to saying in the same breath, are located only about 4° apart in the sky. After being so close to one another in our sky for years, it's easy to forget that a century from now they'll have moved to opposite sides of the sky.

The remaining bright planet, **Saturn**, is easy to see high in the south during November, setting at around midnight. Though Saturn is not overwhelmingly bright at magnitude 0.9, it does stand out in a relatively star-poor region of Aquarius the Water Carrier. Note the golden color of its light. Look for the First Quarter Moon near it on November 2. On November 22 Saturn is stationary, poised motionless among the stars. This means that the best time of year to see this narrow-ringed world is coming to an end.

A telescope reveals something surprising about Saturn in November. Generally, even small telescopes show a ring system that girdles the planet. But every 15 years Earth passes through the plane of Saturn's rings. When this happens, the kilometer-thick rings appear edge-on and, for a brief time during the passage, even disappear.

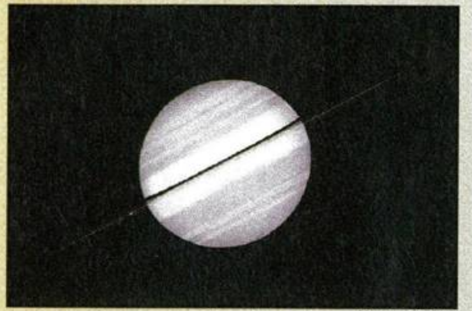
The Moon Meets a Ringless Saturn



Looking southeast, early evening

If you've never seen Saturn before, finding it on the night of November 2 and 3 will be a piece of cake. The Moon slides 6° north — about 12 Moon diameters — of the ringed planet. In the early evening hours, both are high in the south. Saturn is the only bright, steadily shining object in this part of the sky and has a peach color.

Should this be your first look at Saturn in a telescope, you may be disappointed to find the rings exceedingly difficult to spot. In fact, they'll be almost edge-on and appear pretty close to what the drawing below shows. But this isn't a bad thing; consider yourself lucky to have front-row seats as the ringed planet undergoes a marvelous transformation.

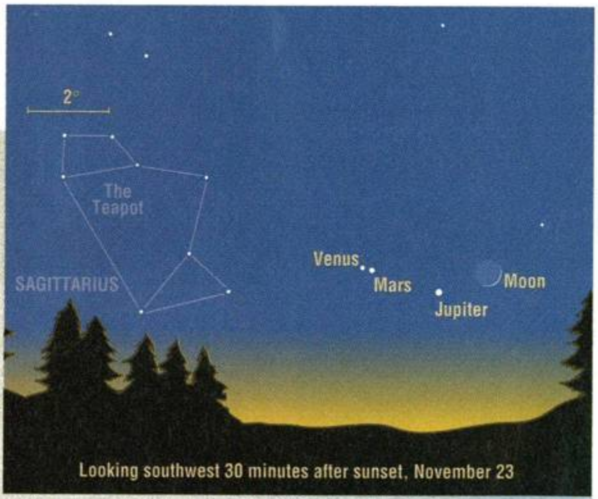


Charles Capen

On November 19 the gossamer-thin rings become backlit by the Sun, giving Earth-bound observers a chance to see the "dark side" of Saturn's rings. This only lasts until February 11, when the Sun and Earth again lie on the same side of Saturn's ring-plane.

Don't miss this play of geometry and light, for your next opportunity won't come until 2009 (see "The Vanishing Rings of Saturn," June 1995). — *A. L.*

Evening Planets Huddle



Looking southwest 30 minutes after sunset, November 23

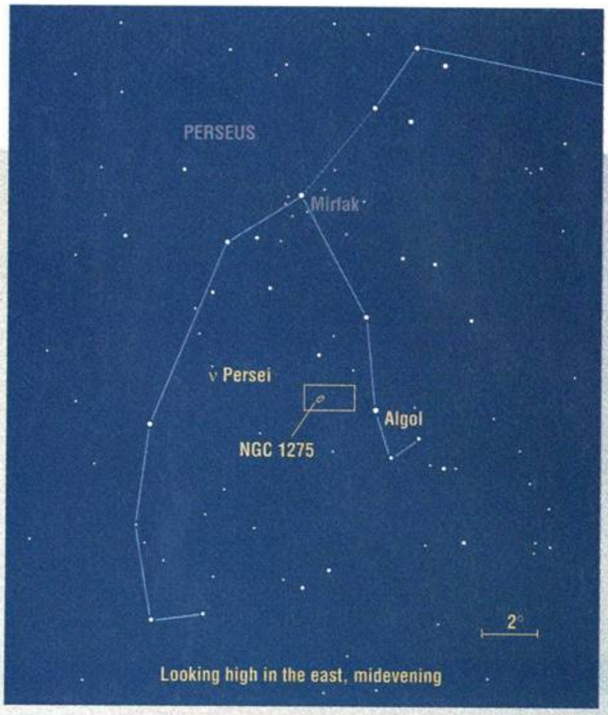
The evenings of November 20 through 23 present a veritable feast for observers. On those three nights, Jupiter, Mars, and Venus lie within a 5° circle, with the 33-hour-old thin crescent Moon joining in on the 23rd.

On November 20, 1.3-magnitude Mars is less than 1° to the upper left of the blazing –3.9-magnitude Venus. By the 22nd, the bright, gibbous-phased Venus slides a mere 12' (the typical field of view in a telescope working at high power) south of tiny Mars, which is only 4" across. It's been four years since two planets occupied the same field of a high-power eyepiece.

By November 23, the two planets increase their separation to 41', still within a low-power field of view. All told, a scope working at low power shows both Mars and Venus in its field of view for five evenings in a row. Even as their separation widens each evening, their difference in brightness will make it a challenge to split them with the naked eye.

The highlight of "conjunction week" occurs on November 23, when the planets and crescent Moon shine through twilight colors. At latitude 40° north, this happens at 45 minutes after sunset. Spot Venus 30 minutes after sunset and use it to find the crescent Moon and Mars. Binoculars will be your instrument of choice to witness this awesome celestial ballet. — *A. L.*

Observer's Challenge:
NGC 1275 and Its Galaxy Cluster



Looking high in the east, midevening

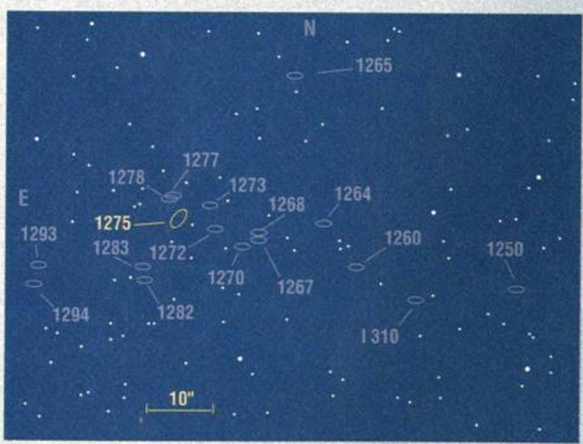
Stretching across a major chunk of fall sky from Pisces to Perseus is a long, knotty string of galaxies. This string, some 250 million-light years away, is part of the spongy universe that cosmologists have been talking about. Along this galactic superstring shines an 11.6-magnitude Seyfert galaxy called NGC 1275, which glows about a magnitude fainter than the faintest Messier galaxies. This bizarre object may look like a run-of-the-mill galaxy, but NGC 1275 puts out an immense amount of radio energy from its core. It also anchors a faint, rich grouping of galaxies called the Perseus Galaxy Cluster, a popular target for observers with large telescopes.

The easiest way to find NGC 1275 and its attendant cluster is to first center on Algol and then move 2.2° along a line Algol forms with Nu (ν) Persei. A 6-inch scope under quite dark skies is about the minimum aperture you'll need to tackle NGC 1275. A 10-inch at moderate power, under fair country skies that offer a limiting magnitude of 6, reveals three other nearby galaxies: NGC 1270, 1272, and 1273. Where NGC 1275 has a bright stellar core with a small fuzz around it, NGC 1272 appears uniform but significantly fainter. NGC 1270, is fainter still (magnitude 13), and requires more than 150x to see a shape. All I can see of NGC 1273 in a 10-inch scope is its stellar core.

A 14-inch or larger telescope under dark skies nets dozens of galaxies in the immediate area of NGC 1275. To spot these elusive objects, wait until late evening when the cluster is high in the sky and use the accompanying finder chart as a guide. Most of all, be patient as your eye learns to pick the faint fuzzies out from the sky glow.— *A. L.*

THE PERSEUS GALAXY CLUSTER

NGC	R.A. (2000)	Dec.	Mag.	Size
1250	3h12.4m	41°21'	14.2p	2.7'x1.1'
1310	3h16.7m	41°20'	12.7p	1.6'x1.6'
1260	3h17.5m	41°24'	14.2p	1.7'x0.8'
1265	3h18.3m	41°52'	14.7p	2.1'x1.9'
1267	3h18.7m	41°28'	13.0	1.4'x1.1'
1268	3h18.8m	41°29'	14.2	1.2'x0.9'
1270	3h19.0m	41°28'	12.9	1.1'x0.9'
1271	3h19.2m	41°21'	13.9	20"x20"
1272	3h19.3m	41°29'	12.5	2.5'x2.3'
1273	3h19.4m	41°32'	12.9	1.4'x1.4'
1275	3h19.8m	41°31'	11.6	2.6'x1.9'
1277	3h19.9m	41°34'	13.5	0.8'x0.3'
1278	3h19.9m	41°34'	12.6	1.7'x1.4'
1282	3h20.2m	41°22'	12.9	1.7'x1.3'
1283	3h20.3m	41°24'	13.6	1.3'x0.8'
1293	3h21.6m	41°24'	13.3	1.1'x1.1'
1294	3h21.7m	41°22'	13.1	1.8'x1.6'



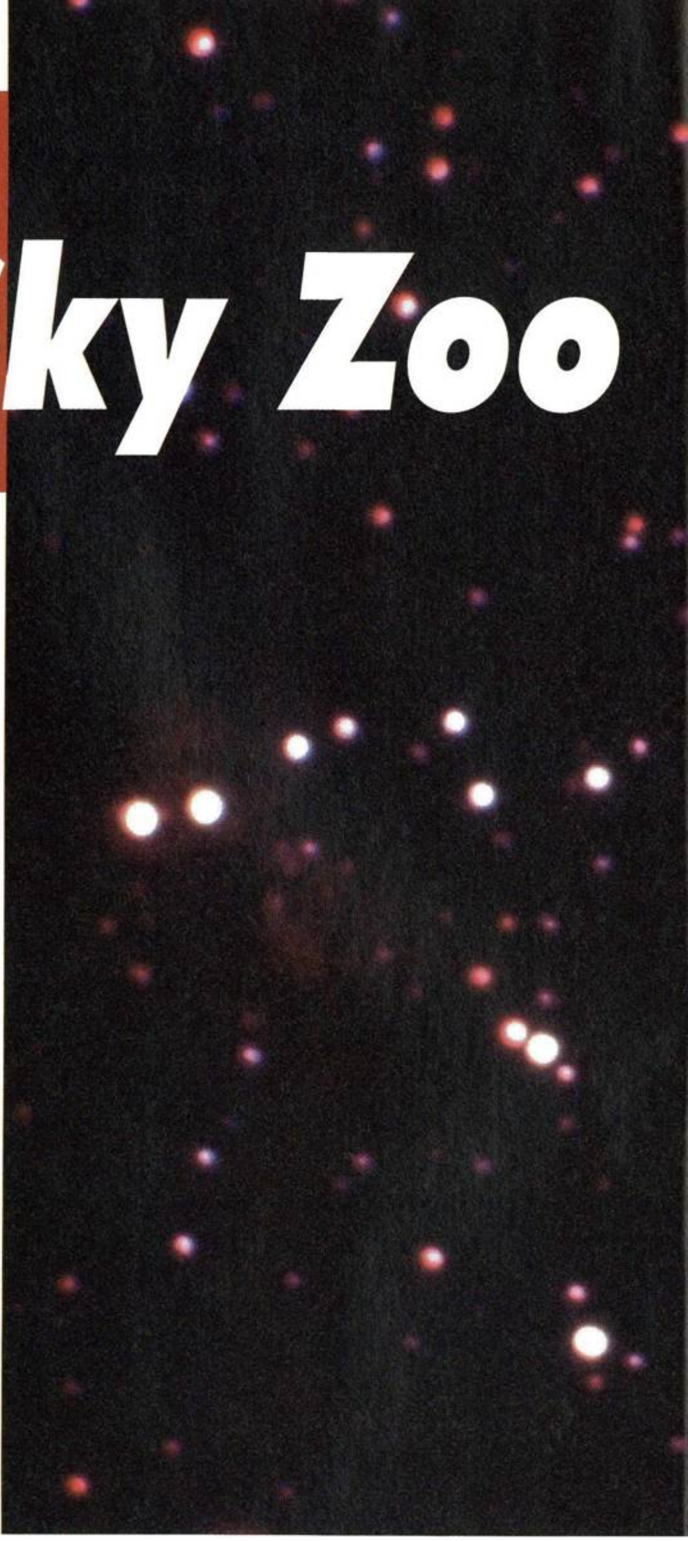
Through 1995 and into early 1996, we pass three times through Saturn's ring-plane. The first time was in May; the second was in August; the third and final time will be in February.

But November offers a slightly different ring spectacle. This month the rings are edge-on not to us but to the Sun. The sun-centered or heliocentric ring-plane passage takes place on November 19. For the next three months we will see the rings backlit by the Sun.

And what of the other planets this month? Two worlds, one usually bright and one always faint, are missing from the night sky this month. **Mercury** is headed behind the Sun after finishing an excellent predawn apparition in late October. Its superior conjunction takes place at 5h UT (midnight EST) on November 23. It so happens that faint **Pluto** has a conjunction with the Sun two hours after Mercury's. You might imagine these two little worlds on that day — the innermost and outermost planets in our solar system, separated by billions of miles — crossing the sky from dawn until dusk, consumed in the daylight glare of the Sun. ☐

Deborah Byrd writes and produces the daily "Earth and Sky" radio series. Deep-sky object hunter Alister Ling is a meteorologist with Environment Canada.

Visit the Deep-Sky Zoo



It's in your sky every night, a universe of eagles, owls, swans, butterflies, and crabs — creatures that await your visit with a pair of binoculars or a small telescope.

by Edmund A. Fortier

A myriad of beasts circles the sky each night, offering sights that will delight the most jaded skywatcher. Visible to the eye alone, in binoculars, and in telescopes, is an array of star clusters and nebulae that look for all the world like creatures we see in zoos and backyards, scurrying across the land or perching in the trees. Checking out a few of these celestial animals will return you to the spirit of observing for the sheer fun of it and delight your friends who don't go out and observe the sky. Give these creatures a try on a clear night soon.

A good place to start is with the open cluster NGC 457 in Cassiopeia. Nicknamed the **Owl Cluster**, this object lies 2° southwest of Delta (δ) Cassiopeiae and shines at magnitude 6.4, which means it is just visible to the naked eye on a dark night. A relatively young group, NGC 457 contains about 80 stars spanning 13'. The brightest in the field is 5th-magnitude Phi (ϕ) Cassiopeiae, a yellow-orange supergiant and one of the most luminous stars known. Just to its west lies another prominent star, 7th-magnitude HD 7902. Although these two luminaries dominate the group, neither is an actual member of the cluster.

Observe NGC 457 with moderate magnification and you'll notice its distinctive owl-like appearance. The two bright interlopers mark the owl's eyes, while several dozen 9th- and 10th-magnitude suns outline the body, feet, and outstretched wings.

Although bright open clusters are easy to observe, nebulous objects pose a greater challenge. In 1731 John Bevis discovered a small hazy nebula in Taurus, later cataloged by Charles Messier as the first entry, M1, in his list of cometlike objects. But not until 1844, when Lord Rosse turned his giant 72-inch reflector on M1, did its fine filamentary structure show up. Rosse dubbed M1 the **Crab Nebula**.

Today we know the Crab (NGC 1952) is a supernova remnant, the chaotic aftermath of the explosive death of a star that occurred nearly 1,000 years ago. Lying 6,300 light-years away, the Crab measures several light-years across and is still expanding outward at a furious rate. At its center, a massive spinning neutron star pulses 30 times a second.

Situated just over a degree northwest of Zeta (ζ) Tauri, the magnitude 8.4 Crab is not difficult to find. But don't expect to see the intricate, spidery tendrils that make photographs of the Crab so spectacular. Even Lord Rosse with his 72-inch scope was barely able to detect these wispy filaments. Still, modern telescopes are far more efficient than the ones Rosse used and they provide tantalizing views. In a 6-inch scope, the Crab appears as a

The Swan Nebula (M17)
by Emery Hildebrand

faint, gray patch of nebulosity, basically oval in shape. Larger scopes reveal a patchy, mottled surface and irregularities around the nebula's ragged edges.

The Crab is a recent name; the lore surrounding some deep-sky objects stretches back to antiquity. Such is the case with M44 (NGC 2632), a large, loose open cluster in Cancer. At magnitude 3.1, M44 is easily visible to the unaided eye and was well-known to the ancients, who called it the **Beehive**. In fact, ancient skywatchers used the Beehive to forecast weather. Because high cirrus clouds from an advancing weather front obscure the cluster, its disappearance from a dark sky signals an approaching storm. In 1610, Galileo viewed the Beehive

The Crab Nebula (M1)
by Barry Sobel

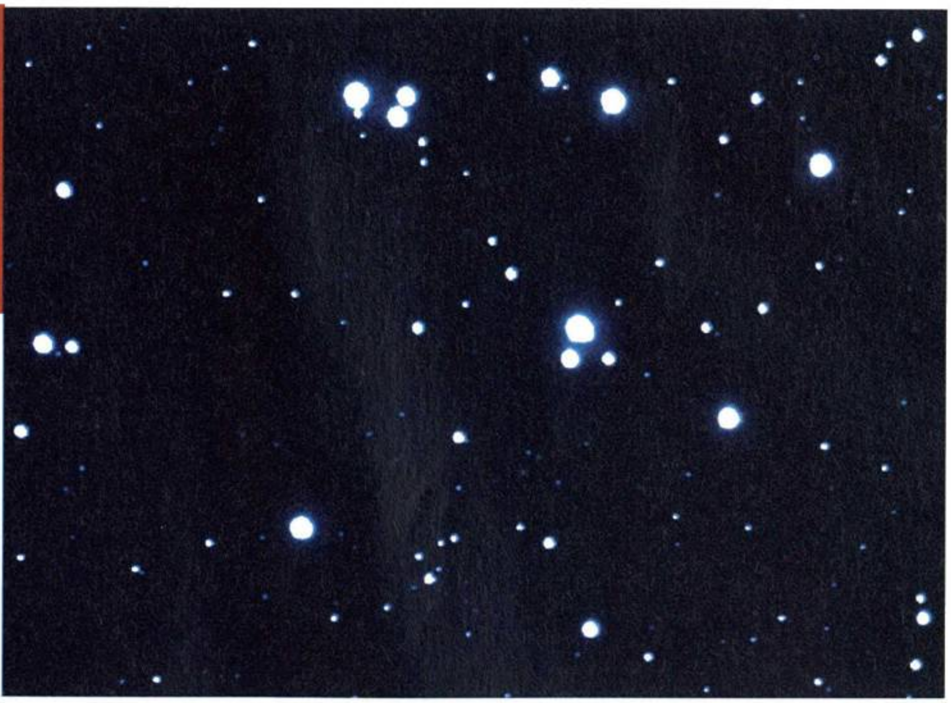
Cluster through his telescope and was astonished to see the ghostly cloud transformed into a cluster of sparkling stars. He counted 36 cluster members.

To find the Beehive, look a degree southwest of Gamma (γ) Cancri. Gaze patiently for a faint sheen of light roughly twice the size of the Full Moon. The cluster contains some 50 stars and measures 95' across, so it is best observed with binoculars or a small telescope at low power. Though the Beehive acquired its name long before the time of Galileo, many of its bright, scattered stars are yellow or slightly orange in color and do, in fact, resemble a swarm of bees.

North of the Beehive lies one of the most challenging objects in the celestial zoo, the **Owl Nebula** (M97, NGC 3587), a 12th-magnitude planetary nebula in Ursa Major. Discovered in 1781 by French observer Pierre Méchain, the Owl is large for a planetary, measuring over 3' across. Méchain observed only a misty disk. The first observer to detect structure in the Owl was the mid-nineteenth-century observer William Parsons, the Third Earl of Rosse. The nebula's popular name stems from one of Rosse's sketches, made in 1848, which showed two distinct dark areas, the owl's eyes, within the disk.

The Owl Nebula lies 2½° southeast of Beta (β) Ursae Majoris, just beneath the bowl of the Big Dipper. While the disk itself is visible as a featureless patch of gray in medium-size telescopes, the dark areas that constitute the owl's eyes are much more difficult to see. To observe them, wait for a moonless night, allow your eyes to

The Owl Cluster (NGC 457)
by Bernard Abrams



The Beehive Cluster (M44)
by Pedro Ré

become fully adapted to the dark, and be sure to use averted vision, glancing to the side of the eyepiece field.

Moving our tour to the southern sky, look 9° east and a little north of 2nd-magnitude Epsilon (ε) Scorpii for the **Butterfly Cluster** (M6, NGC 6405). Even in a small telescope this object is a grand sight. Dimly visible to the naked eye, its 80 members fill a 15' field and shine with the combined light of a magnitude 4.2 star. As with NGC 457 in Cassiopeia, the Butterfly Cluster's appearance in a telescope is so distinctive that it's difficult to imagine it by any other name.

The Butterfly is a young cluster, only about 50 million years old, so most of its brightest members are hot, B-type stars. In a wide-field eyepiece, these diamond-white points take on the unmistakable shape of a butterfly, the whole figure seemingly superposed on a rich field of fainter stars. Adding a touch of color to the tip of one wing is 6th-magnitude BM Scorpii, a semiregular variable with a conspicuous orange hue.

Younger than the Butterfly, the **Eagle Nebula** (M16, NGC 6611) in Serpens is a delight. From a dark site, this 6th-magnitude cluster is just visible to the naked eye 6° southeast of Nu (ν) Ophiuchi. The Eagle takes its name from details visible only on long-exposure photographs. Such pictures reveal a spectacular and intricate interplay of bright and dark nebulosity, eagle-like in shape. The nebula is within reach of backyard telescopes, though only as an amorphous haze.

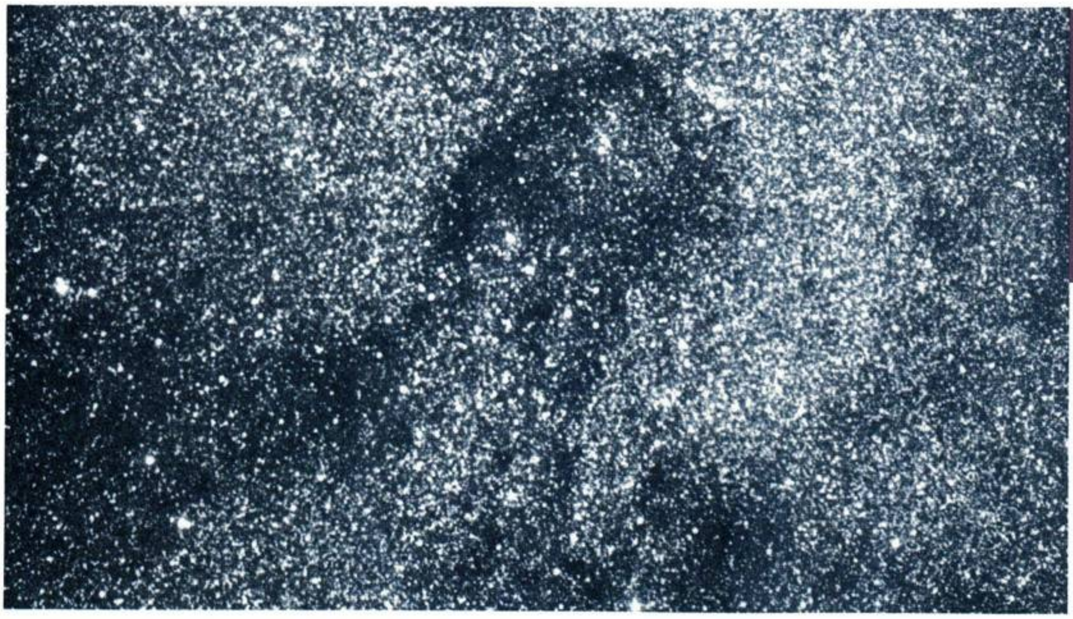
As with the Owl Nebula, a good view of the Eagle requires a medium-size telescope and a moonless night. If conditions are favorable, you may see hints of the dark areas visible on photographs, particularly the prominent wedge-shaped intrusion that defines one side of the eagle's tail. Another feature accessible to backyard telescopes is the dark region that nearly bisects the Eagle. British astronomer Fred Hoyle called the projections in it "elephant trunks."

The **Swan Nebula** (M17, NGC 6618) in Sagittarius, discovered by De Chéseaux in 1764, lies just 3° south of the Eagle. It is also a stellar nursery, but unlike the Eagle, its stars are mostly hidden by opaque clouds of dust and gas or lost in the surrounding starfield. The Swan has a high surface brightness, which suggests that the stars concealed within it are highly energetic. At magnitude 6.0, it is an easy object for small and medium-size instruments.

The Swan's most conspicuous feature is a luminous smear of nebulosity, the swan's body, about 7' long. A gently curving extension rises from the west side of the body, forming the neck and head. Centered in a wide-field eyepiece, the Swan is perhaps the most evocative of any nebula, a spectral swan on a starry sea.

Another bird in Sagittarius is the **Parrot's Head Nebula** (B87), located midway between Gamma Sagittarii

The Owl Nebula (M97)
by Jack Newton



The Parrot's Head Nebula (B87)

by Martin C. Germano

and M7 in Scorpius. The name is attributed to the late 19th-century astronomer Edward Emerson Barnard, who cataloged the object as the 87th in his atlas of dark nebulae. The Parrot's Head is roughly oval in shape and measures 12' in diameter. Although it's visible in small scopes, B87 looks more parrotlike in photographs.

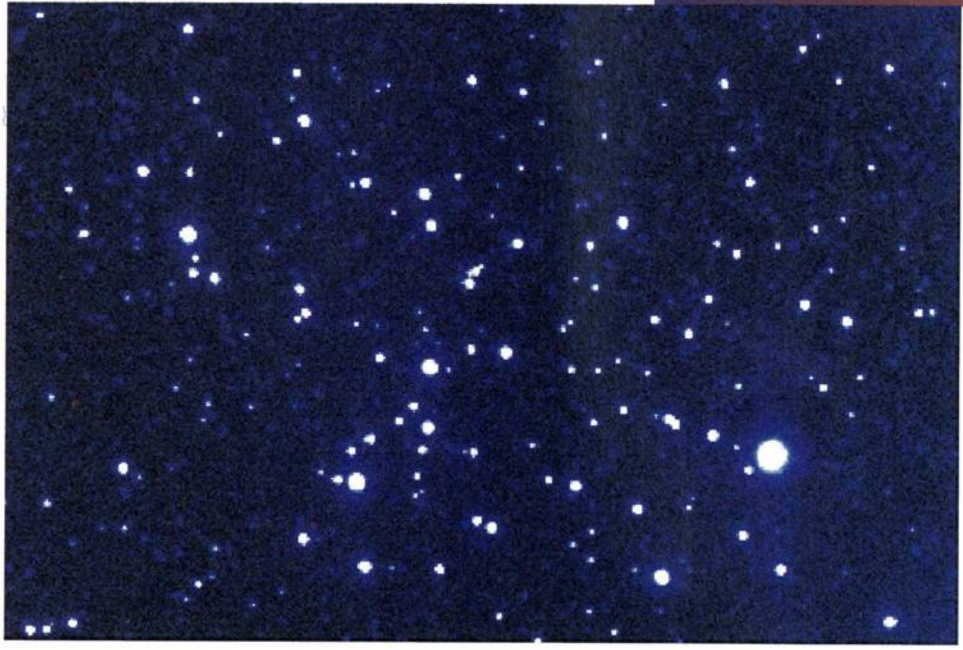
One of the richest open clusters in the sky is M11 (NGC 6705) in Scutum, known as the **Wild Duck Cluster**. In the minds of many skywatchers, the cluster really belongs to William H. Smyth. In his classic *Cycle of Celestial Objects*, published in 1844, Smyth compared the cluster's compact, fan-shaped appearance to a flight of wild ducks, a casual remark that has struck a lasting chord.

Lying in a rich region of the summer Milky Way, about 2° southeast of Beta Scuti, the Wild Duck contains several hundred stars crowded into a 14' field. While the group's total magnitude is 5.8, most of its members range between magnitudes 11 and 14. Its brightest star, located near the center, shines at 8th magnitude and stands out in small telescopes.

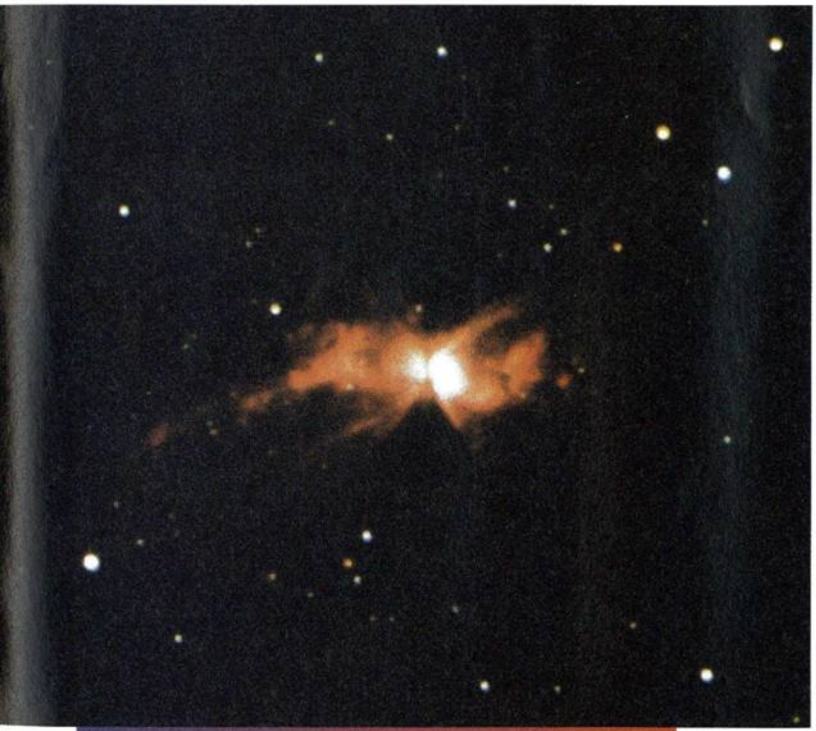
Some faint deep-sky objects owe their names to details that can only be detected photographically. The

The Butterfly Cluster (M6)

by Pedro Ré



The Eagle Nebula (M16)
by Jack Newton



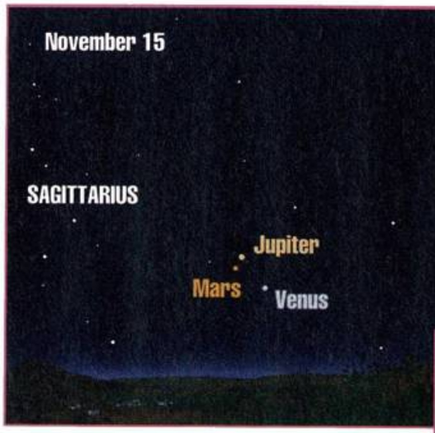
The Bug Nebula (NGC 6302)
by Jack Marling

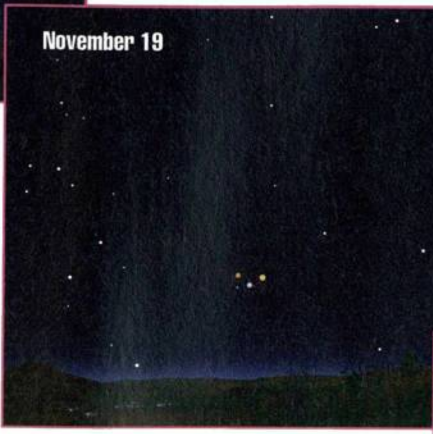
Bug Nebula (NGC 6302) in Scorpius is a 12th-magnitude glow measuring just 2' by 1'. Its curious bipolar structure is visible in backyard telescopes, but not the irregular clawlike appendages that give it its name. Similarily, the Pelican Nebula (IC 5067-70) in Cygnus and the Horsehead Nebula (IC 434) in Orion assume their familiar shapes only on long-exposure photographs. In Coma Berenices, the twin 14th-magnitude galaxies nicknamed the Mice (NGC 4676A and NGC 4676B) are mere smudges of light in the largest amateur telescopes.

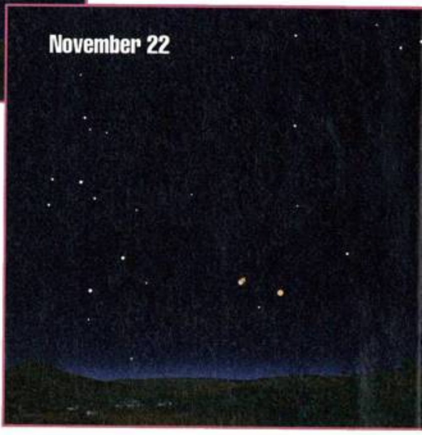
Deep-sky observing, for the most part, is an aesthetic and intellectual experience. But don't forget its imaginative side. The more we observe these denizens of the celestial zoo, the more we tend to see them as islands of order in a vast, overwhelming universe. Just like our ancestors, we want the night sky to be a familiar and orderly place — even if we have to make it that way ourselves. □

Edmund Fortier is a frequent contributor to ASTRONOMY*. His last observational article was "Winter's Evening Planets," February 1993.*

A Stunning Planetary Trio

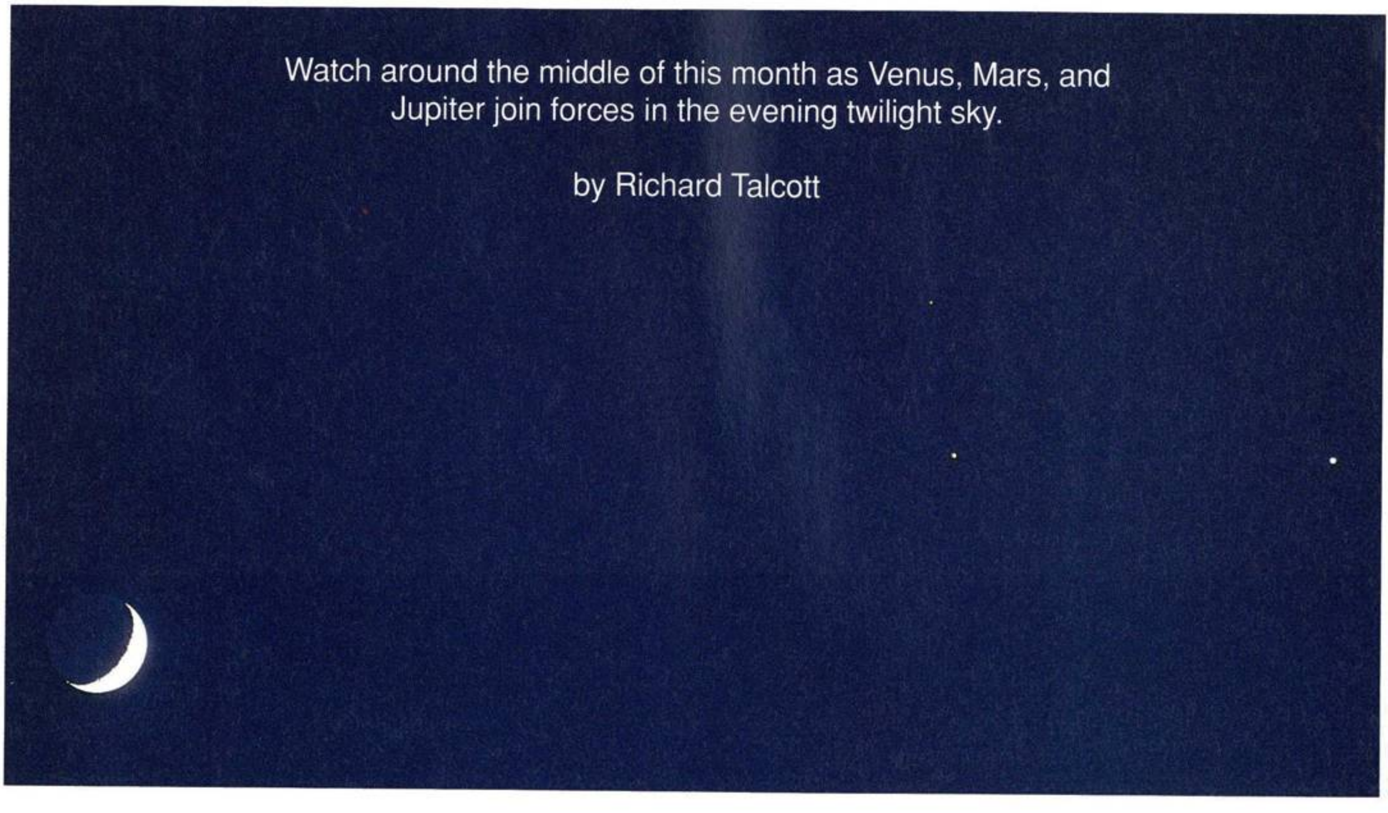






A celestial drama unfolds in the gathering twilight this November. The stage: the southwestern evening sky, where the brilliant golds, reds, and purples of twilight provide a gorgeous autumn backdrop. The "stars" of the show are not stars at all, however, but the planets Mars, Venus, and Jupiter. A cameo by the crescent Moon will draw a large crowd among the general public and seasoned stargazers as well.

The action actually began early last month, when Venus returned as the evening star for the first time in nearly a year. At magnitude –3.9, the brightest planet spent October rising slowly higher in the dusk. As it did, it climbed closer to both Mars and



Watch around the middle of this month as Venus, Mars, and Jupiter join forces in the evening twilight sky.

by Richard Talcott

Brian Kimball

Jupiter, which had been hanging around the evening sky throughout the summer and fall but were sinking slowly toward the horizon.

As the October preliminaries came to a close, the stage was set for a much more eventful November. When the month opens, the three planets form a straight line stretching diagonally above the southwestern horizon. Venus remains lowest, appearing at an altitude of 4° half an hour after sunset. At the same time Jupiter, the highest of the three, rides 13° above the horizon. Shining at magnitude –1.9 (making it the fourth brightest object in the sky after the Sun, Moon, and Venus), it appears conspicuous against the twilight.

Mars lies roughly halfway between the other two and glows significantly fainter at magnitude 1.3. Don't confuse it with Antares, the brightest star in Scorpius, which lies just 4° to the lower left of Mars. The two objects share the same ruddy hue and, at magnitude 1.0, Antares is actually a bit brighter than Mars.

As November progresses, Venus climbs rapidly away from the horizon while the others continue sinking. Jupiter sinks faster than Mars, so the net effect is that the three pull ever closer to one another. They remain quite low in the sky and immersed in bright twilight, however, so you'll want to look for them from a site that offers a view toward the southwest unobstructed by hills, trees, or buildings.

By November 14, all appear within 5° of one another. A pair of binoculars will nicely frame the trio, but don't feel you have to magnify the view. Often the people who get the most pleasure from viewing this type of planetary conjunction are those who take in the grand sweep afforded by the naked eye.

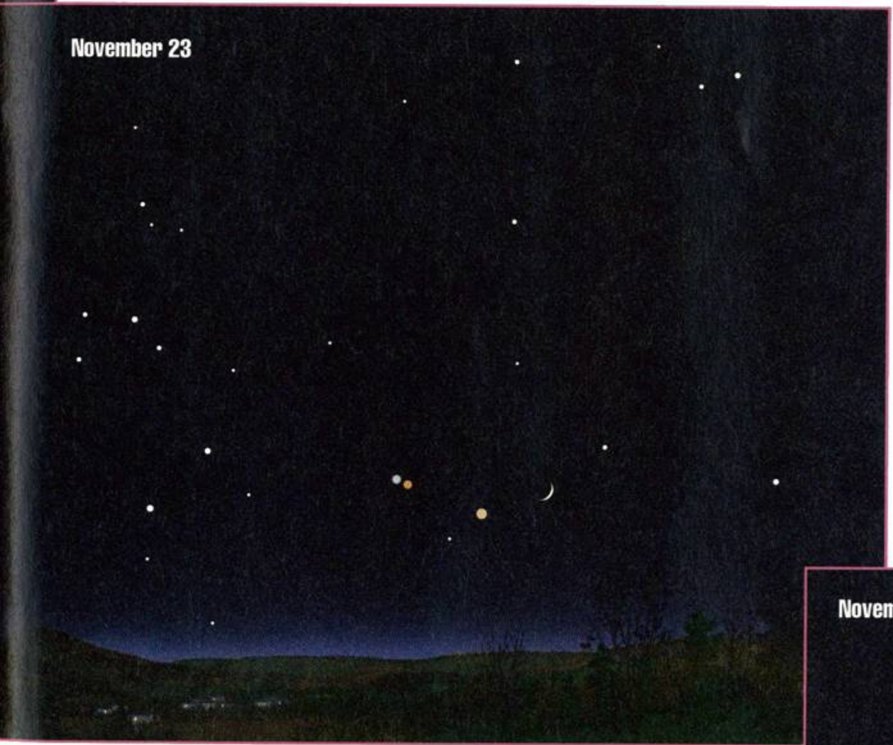
The first of three close conjunctions among the planets takes place on the morning of the 16th, when Mars passes 1.2° south of Jupiter. From North America, the best view comes on the evening of the 15th. The second occurs three days later, when Venus lies 1.3° south of Jupiter. Observers in North America will get good views on the evenings of both the 18th and 19th. Those two evenings also mark the closest approach of all three planets, when they fit within a circle 2° across.

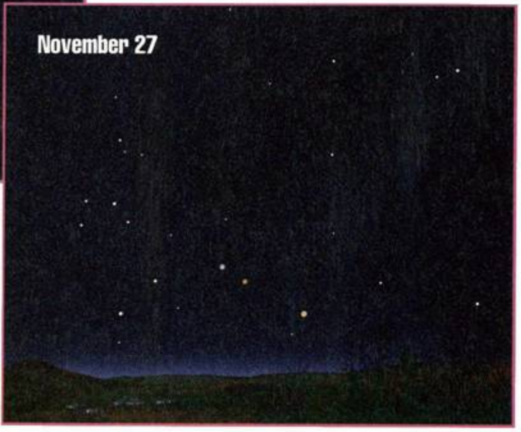
This provides a good chance to compare the brightnesses and colors of the planets. Venus easily ranks as the brightest of the three, shining some seven times brighter than Jupiter, while Jupiter glows nearly 20 times brighter than Mars. Although more subtle than the brightness differences, the color contrasts among the planets are striking, particularly when viewed in binoculars. Mars has a distinct orange-red color that stands out, while Venus appears a brilliant white and Jupiter is slightly cream-colored.

The last and closest of the three planetary conjunctions arrives on November 22, when Venus passes 0.2° south of Mars. The proximity of the two planets combines with good timing to make this the most spectacular of the conjunctions for North American observers.

But the climax of this celestial drama comes the next evening, when the Moon turns the trio into a quartet. The crescent Moon, just 3 percent lit and brimming with earthshine, lies 4° to the upper right of Jupiter that evening. Venus and Mars, still extremely close to one another, are about 8° to the left of the Moon.

The excitement dies quickly as November comes to a close. Both Jupiter and Mars disappear into the Sun's glare during December and will be lost from view until next year. Venus goes on to perform a fine solo act in the evening sky, dominating the view all winter and spring. But the mighty trio of Venus, Jupiter, and Mars won't cluster as closely on center stage for more than a century. ☐





FOUR YEARS AGO, the Moon joined Venus, Mars, and Jupiter (left) in a gathering that closely resembles the one coming up this November (above).

Big On Celestial Photography

by Mark J. Coco and Scott W. Roberts

Medium- or large-format cameras can produce portraits of sky objects worthy of gallery walls.

Want a creative way to challenge your astrophotography skills and produce high-quality, razor-sharp portraits that will dazzle your astro-friends? Medium- and large-format cameras offer advantages over their smaller format counterparts like 35mm. Medium- format cameras are those whose film size is roughly 2¼" square. For example, Pentax offers a popular 6 x 7 cm format camera that's considered medium format. Large format cameras are those that hold even larger pieces of film, the most common sizes being 4 x 5 and 8 x 10 sheet film. Rather than collecting light on a small chip of 35mm film, these larger format cameras allow you to record starlight onto much bigger negatives or transparencies.

Why Move to a Larger Format?

The advantages of medium- and large-format cameras vary depending on what you want to photograph.

Suppose you want to place your camera on a tripod and use its normal lens, capturing a wide swath of sky. Medium- and large-format cameras provide significantly greater resolution than their 35mm counterparts when used with lenses of the same focal length. Switching lens focal lengths between different format cameras does have its complexities, however.

For example, a 50mm lens attached to a 35mm camera produces a different magnification and field of view than the same focal length lens mounted on a medium-format camera. A 50mm lens on a 35mm camera is considered a normal lens, that is, it

The North America Nebula

by Alfredo Zanazzo

(16-inch f/4 SCT, hypersensitized Tech Pan film, 4 x 5 camera)

The Milky Way in Crux and Carina

by Luke Dodd

(55mm lens at f/4, hypersensitized Fuji 400 film, Pentax 6 x 7 cm camera, composite of two 20-minute exposures) provides a magnification of 1x. A 50mm lens on a medium-format camera is in effect a wide angle lens. The equivalent 1x lens for a medium-format line is 80mm. This is a key distinction to remember when selecting the right lens for a particular shot.

The improved resolution is a big benefit. The reason for it is simple: the amount of sky "seen" by the lens falls onto a much larger piece of film. The same area of sky is captured on a larger piece of film, resulting in improved resolution. A 20° by 20° area of sky fits onto a 35mm frame. In the medium-format camera, the same amount of sky fits into a frame measuring 2¼" x 2¼". The result is a far sharper image.

The larger apertures of medium- and large-format cameras gather more light in a given amount of time and record fainter stars. This larger aperture also helps achieve better resolution.

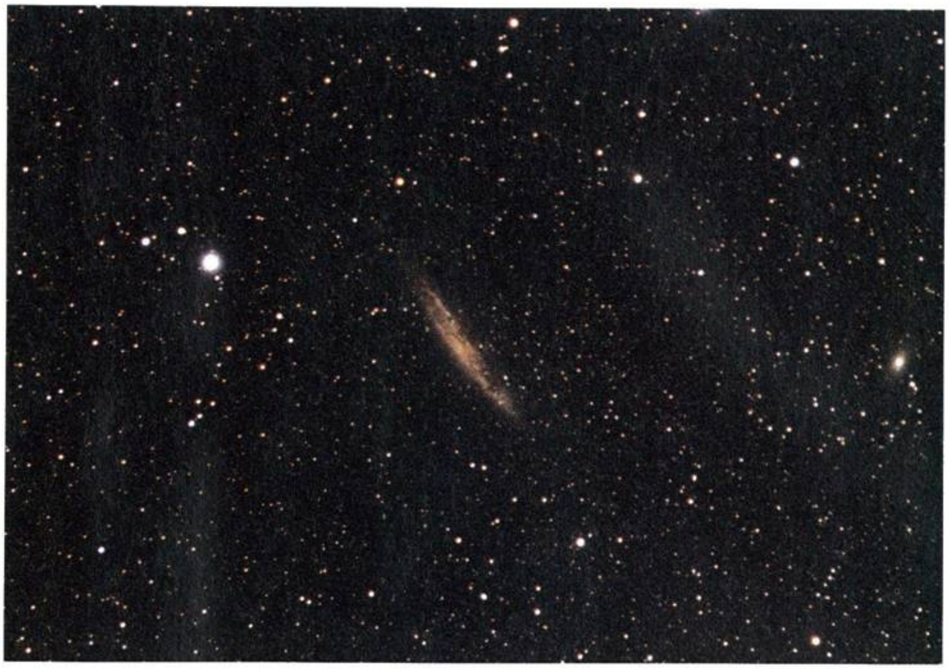
Another advantage of the medium- format camera is that many models have interchangeable film backs. This allows you to load different types of film and shoot the same object with different emulsions in succession. There's no need to use a whole roll of film before loading a new one. With large-format cameras, like 4 x 5 and 8 x 10, the film gets loaded sheet-by-sheet, so you can use an even wider variety of film, a different one for each exposure.

Medium- and large-format photography also offers an advantage to astronomy groups and classes. Polaroid makes a variety of films in large formats for instant astrophotography. This gives photographers the ability to see an image immediately to determine if it is properly centered, focused, and exposed. Furthermore, this "instant astrophotography" application has advantages for astronomy lab classes where students can view their work right after exposing.

Spiral Galaxy NGC 4945

by Luke Dodd

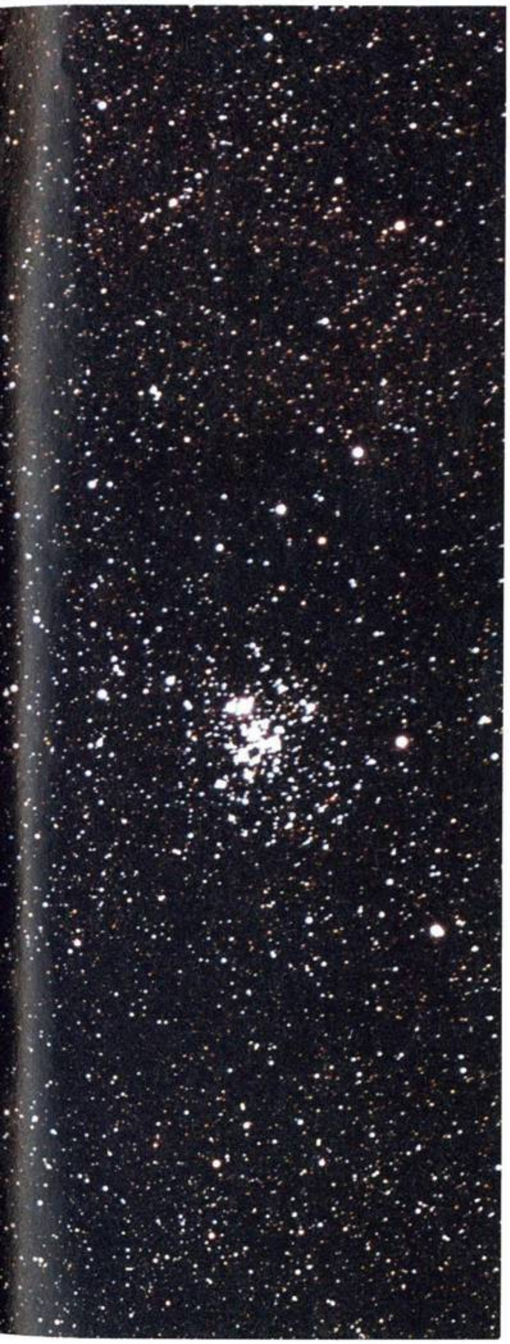
(4.8-inch f/8.5 refractor, Fuji 400 film, Pentax 6 x 7 camera, composite of two 60-minute exposures)

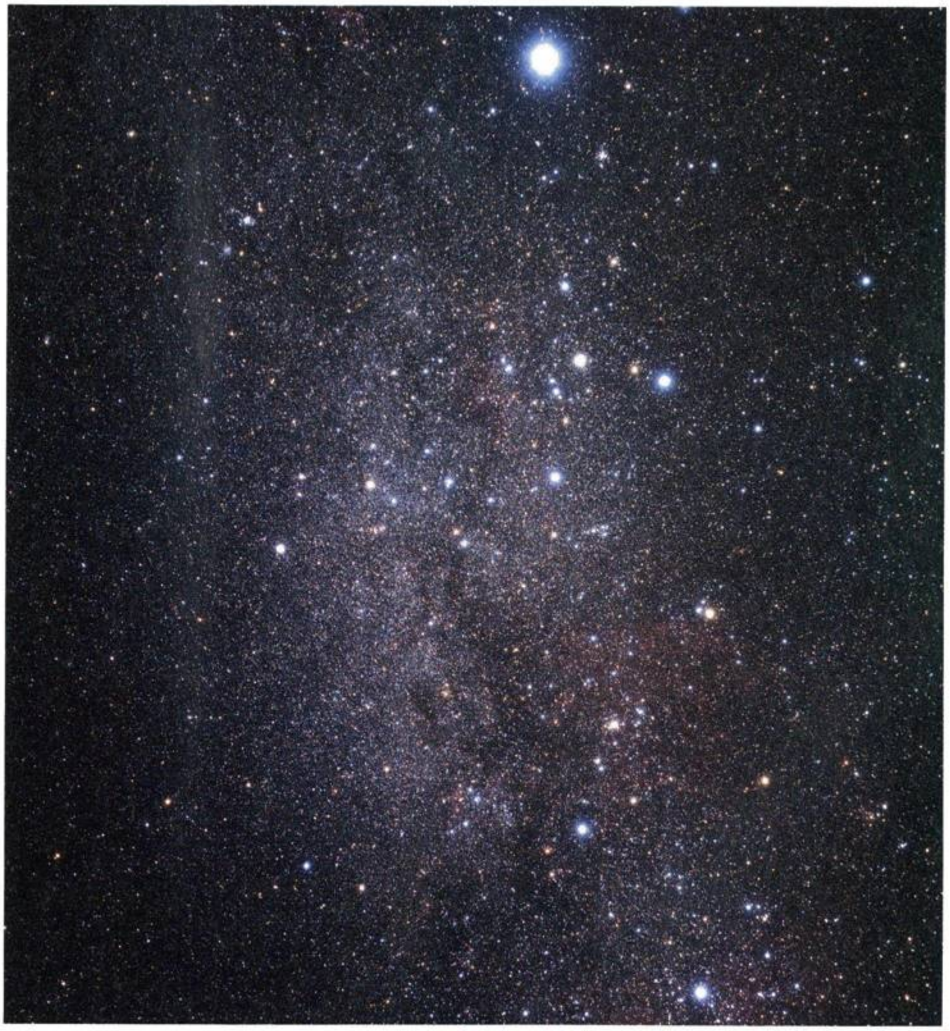


NGC 6231 and IC 4628

by Tony and Daphne Hallas

(7-inch f/7 refractor, hypersensitized Fuji Super HG 400 film, 6x7 format)





The Milky Way in Canis Major

by Luke Dodd

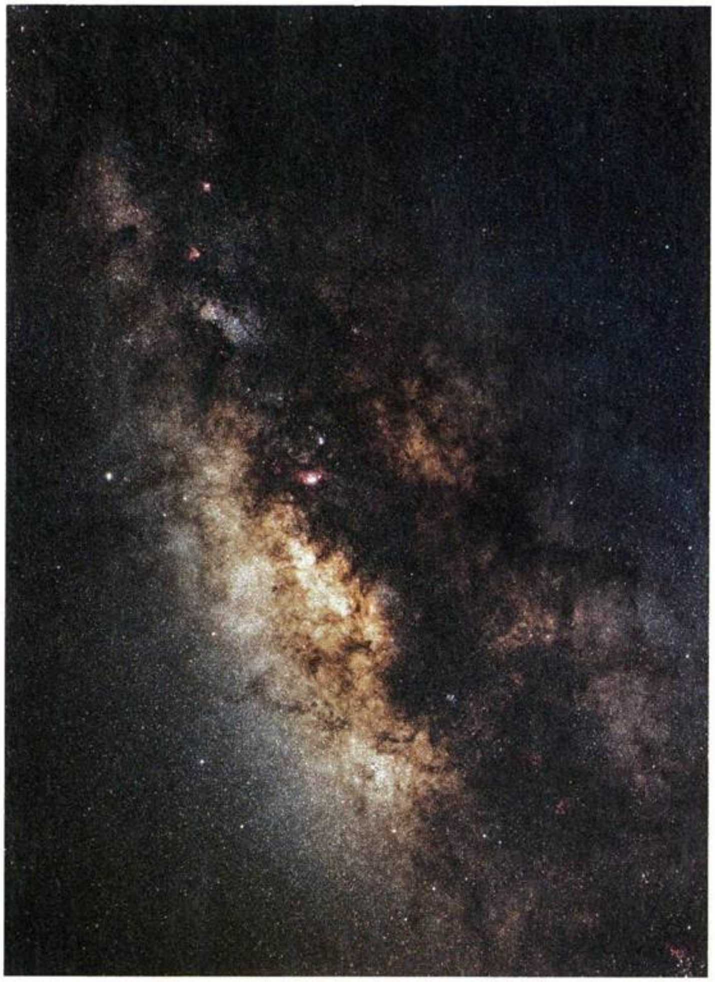
(55mm lens at f/4, hypersensitized Fuji 400 film, Pentax 6 x 7 camera, composite of two 25-minute exposures)

Medium- and Large-Format Cameras

Format	Examples
8 x 10	**Wista, Tachihara, Arca Swiss** Lightweight, flatbed wooden view cameras.
5 x 7	Little is available in the way of film or equipment.
4 x 5	**Tachihara (wooden flatbed),** **Toyo Field (metal flatbed),** **Linhof Technika (light metal flatbed)** This format offers the best selection of film and lenses for large format cameras.
6 x 7 cm	**Pentax 6 x 7**
2¼ x 2¼	**Hasselblad 500CM, Bronica ETRSX 6 x 4.5, Mamiya/Pentax** These are compact systems with the largest array of lenses, film and accessories for medium format cameras.

Films for Medium- and Large-Format Cameras

Film	ISO	Formats
Kodak Ektachrome 64	64	2¼", 4 x 5, 8 x 10
Kodak Ektachrome 100	100	2¼", 4 x 5, 8 x 10
Kodak Ektachrome 200	200	2¼", 4 x 5, 8 x 10
Fujichrome 100	100	2¼", 4 x 5, 8 x 10
Fujichrome 200	200	2¼", 4 x 5, 8 x 10
Fujichrome 400	400	2¼", 4 x 5, 8 x 10
Fujichrome 100D	100	2¼", 4 x 5, 8 x 10
Fujichrome 200D	200	2¼", 4 x 5, 8 x 10
Fujichrome 400D	400	2¼", 4 x 5, 8 x 10
Agfa RS 50	50	2¼", 4 x 5, 8 x 10
Agfa RS 100	100	2¼"", 4 x 5, 8 x 10
Agfa Pan 25	25	2¼", 4 x 5, 8 x 10
Agfa Pan 100	100	2¼", 4 x 5, 8 x 10
Agfa Pan 400	400	2¼", 4 x 5, 8 x 10
Kodak Tri-X	400	2¼", 4 x 5, 8 x 10
Kodak Pan-X	100	2¼", 4 x 5, 8 x 10
Kodak Tech Pan	75	2¼", 4 x 5, 8 x 10



The Sagittarius Milky Way

by Peter Ledlie

(105mm lens at f/3, hypersensitized Fujicolor 100 film, Pentax 6 x 7 camera, composite of two 30-minute exposures)

Solar Eclipse over Baja California

by Roland Christen

(5-inch f/8 refractor, Kodak Ektar 25 film, Pentax 6 x 7 camera, July 11, 1991, from San José del Cabo, Baja California, Mexico)

Shooting through the Scope

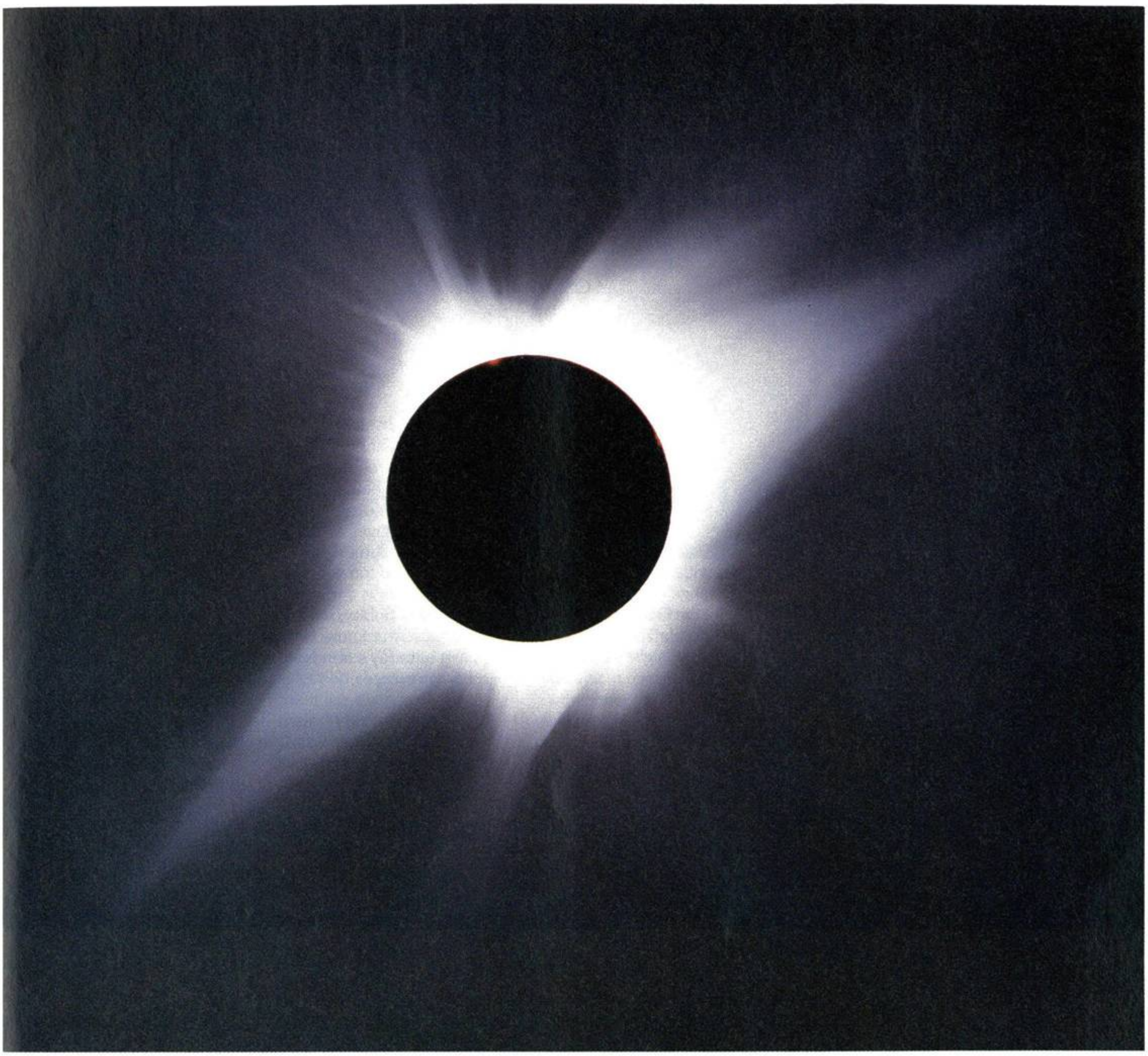
When it comes to shooting medium formats through a telescope, the benefits are mixed. Resolution is unaffected. A 2,000mm telescope provides the same resolution and limiting magnitude regardless of the film size. The advantage comes in field coverage. Large-format cameras record more generous fields simply because the film is larger. This, of course, assumes that the telescope delivers a large enough cone of light to cover the larger format film.

Imagine shooting a galaxy with a 35mm camera attached to your scope and then a large-format camera. The image scale of your galaxy would be no different, but the large-format camera would give you a big piece of film with lots more sky around your subject.

With planetary photography, things are a little different. Medium-format cameras offer no advantages for shooting planets, either through the telescope itself or with eyepiece projection, because a planet's size on the film is identical, regardless of the film format. The only difference is the amount of unexposed film surrounding the image.

Take the Plunge with Care

While the advantages of large-format astrophotography make it well worth considering, the approach does have a few drawbacks. Fewer kinds of film are available for medium- and large-format cameras, and only a small number are valuable for astrophotography (see table). Fortunately, some of the best films, like Kodak's Tech Pan 2415, are available both formats. Another disadvantage is that lens speeds are relatively slow for



medium-format cameras and very slow for large-format cameras. This means that exposures need to be somewhat longer to record as much light as a faster lens with a 35mm setup.

More of logistics problem than a drawback is the greater size and weight of lenses and cameras. Medium- and large-format cameras are, for the most part, heavier than 35mm cameras.

For piggyback photography, consider whether the adapter for your 35mm camera is suitable for a large-format camera. Will the piggyback adapter support the camera? You must also worry more about proper balance of the telescope. If you plan to do prime focus photography, medium- and large-format T-adapters are harder to come by and are generally more expensive. At the present time, few manufacturers offer adapters and those offered are quite expensive.

The last drawback is price. Medium format cameras cost several times more than good 35mm cameras. And the lenses are proportionally more expensive as well.

While the disadvantages may seem weighty, the advantages make this form of celestial photography well worth considering. Many photo shops rent medium- and large-format cameras, making them accessible to anyone for brief periods. Renting such a camera and using it a few times may give you a taste of the trials and benefits of large-format photography. You'll then know if the effort is balanced by the luxurious, beautiful images that can result from these technological wonders. □

Mark J. Coco is a freelance writer and lecturer living in Redondo Beach, California. He has contributed many articles, the latest of which is "Find a Rock in Space" (August 1995). Scott W. Roberts is an avid telescope user living in Irvine, California.

Riverside Reflections

A popular star party lets ASTRONOMY ask amateur astronomers and manufacturers alike where they think the hobby is going.

by John Shibley

For 20-plus Memorial Day Weekends, star-struck amateur astronomers have ascended the mountains outside Los Angeles to see and be seen at the Riverside Telescope Maker's Conference. What they see is the sky through innovative telescopes honed by die-hard amateur telescope makers. The ATMs, for whom only half the fun is observing, come to be seen with their latest creations and to glom ideas from other, kindred souls who also can't get their fill of working with glass, wood, and metal.

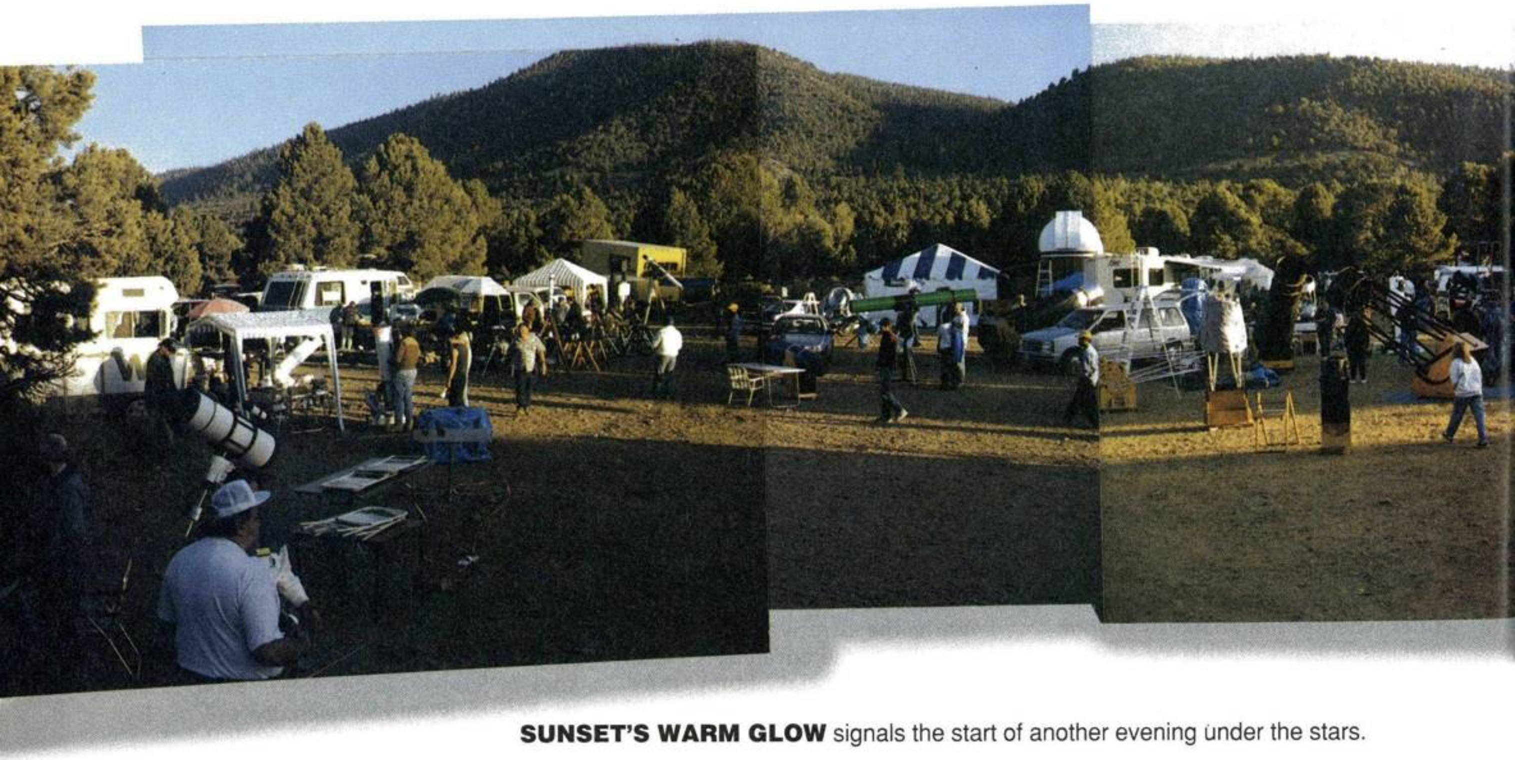
There once was a time when telescope makers paraded really big scopes, ones with mirrors in the 12-inch range, but that was before the Dobsonian revolution made 20-inch scopes a common sight. And Riversiders once marveled at digital setting circles housed in what looked like oversized briefcases. Today that same accessory fits in the palm of your hand.

Planned obsolescence? Hardly. Just a hobby's inexorable march into things that are better, cheaper, and more exciting. What changes await amateur astronomers over the next five or ten years? If Riverside 1995 is a microcosm for the hobby, we can glimpse the future by looking at today's trends and driving forces.

Throw a Party, They Will Come

Sheryl Johnson and Debbie Searle put on star parties for a living, roaming schools and colleges all over Southern California with their Adventures in Astronomy program. In the past two years, 30,000 pairs of eyes have glimpsed the cosmos through their collection of telescopes. The duo's been coming to Riverside since 1987 and have noticed some changes that suit them just fine.

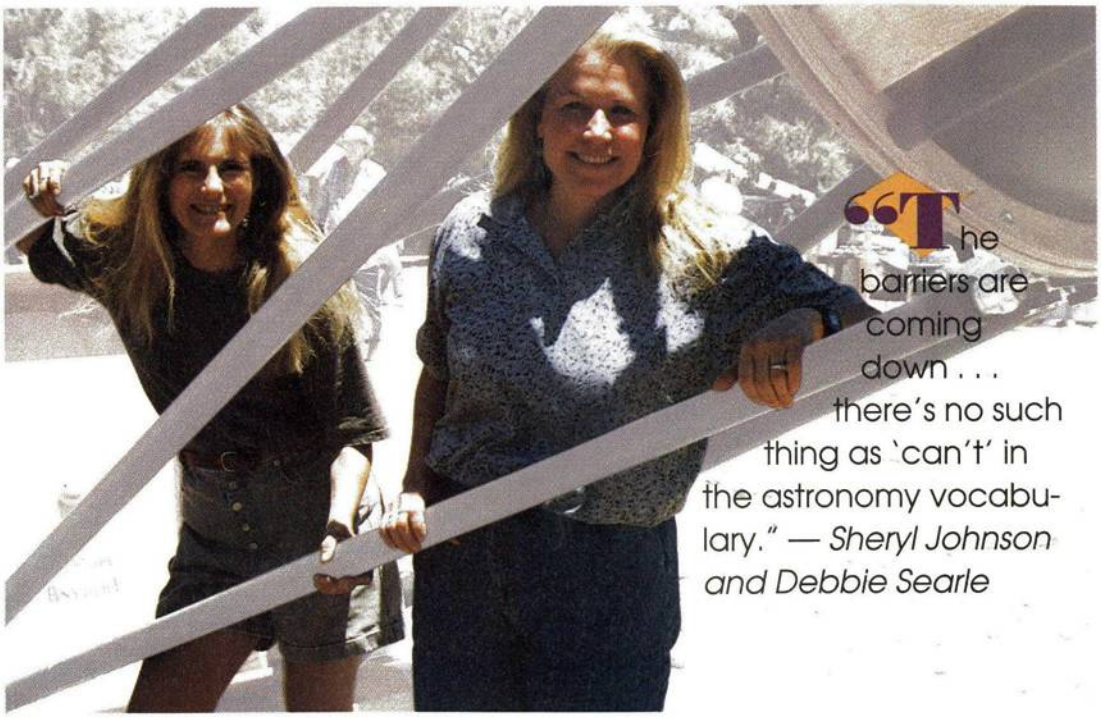
"There's more lighthearted fun and things aren't as intense as they were eight years ago,"



SUNSET'S WARM GLOW signals the start of another evening under the stars.

notes Johnson. "Riversiders seem to be more accepting and respectful of one another's interests." Both Johnson and Searle say it wasn't that long ago when cliques were tighter and more exclusive. "You had deep-sky 'camps' and 'gangs' of planetary observers," says Searle.

Today she notes more crossover between interests, a better appreciation of what good Dobsonian telescopes (best-suited for deep-sky) and top-notch refractors (for planetary observing) can do. "People in the hobby are realizing their full potential through excellent photography and really outstanding deep-sky and planetary observing," she says.



"The barriers are coming down . . . there's no such thing as 'can't' in the astronomy vocabulary." — *Sheryl Johnson and Debbie Searle*

"The barriers are coming down . . . there's no such thing as 'can't' in the astronomy vocabulary," adds Johnson. "You *can* see clouds on Mars or spot the North America Nebula with binoculars, which conventional wisdom well into the 1960s said was impossible."

This comes with no small thanks to the quality, and diversity, of optics on the market. "Such a rich selection of good equipment lets everybody chase their dream and reach it successfully. In 1987 you didn't have all the eyepieces, telescopes, CCD cameras — whatever — to choose from. The hobby's become a smorgasbord," she says.

But equipment doesn't make the hobby; it's the people who have made and will continue to make a difference. "I see more women entering the hobby," says Searle, "which might account for astronomy's more relaxed, less competitive pace. We also see many kids embracing astronomy. It lifts them up and gives them an intellectual frontier."

All photos by Astronomy: John Shibley

Perhaps the largest doorway opening for kids is one that uses computers. "Kids just might fuel the electronic side of amateur astronomy. Their age group is computer-literate and, far from being intimidated, is attracted to the bells and whistles."

Whether purists view this as a blessing or not, the broad consensus at Riverside is that the opto-electronic age is upon us in the form of portable computers, their attendant software, and CCD cameras. Some people have seen the future and it involves the computer chip.

The Universe Is (Virtually) Here

Steve Bisque is riding a wave in the computing revolution. His goal as president of an astronomical software company is to put into the hands of every

BARGAIN HUNTERS GREET the morning at Riverside's legendary swap meet.

astronomy enthusiast the easiest means of viewing and photographing the sky. If that involves a computer, all the better.

"Visual astronomy will still be the most rewarding aspect of the hobby ten years from now," says Bisque. "But by then the computer will be a natural part of the telescope, as natural as an eyepiece." Bisque's world of astronomy has computers completely integrated with telescopes as silicon night assistants. Gone will be the drudgery of aligning a scope and struggling to find elusive objects, be they faint galaxies or diminutive asteroids.

Beyond that, your telescope's computer will serve as field librarian, able to throw up on a screen any and all information about any and all targets you could ever hope to see or image. Shoot a five-minute CCD picture and bring it up on the screen where the computer will dutifully look for supernovae or wayward asteroids. All under open sky to a nocturnal chorus of crickets.

A key factor in this scenario, Bisque stresses, is computer friendliness. "Software is the glue that melds telescope and user. It's got to become more friendly, along with the hardware. I want to provide the software and tools so there's more time to do observing and imaging, rather than getting the scope pointed."

There's even room for those without scopes in Bisque's future. Right now, Software Bisque works with the Mount Wilson Observatory in California to provide schools remote access, by computer modem, to telescopes on the observatory's grounds. Educators and students from all over the world use this program to "observe" the sky through a CCD camera attached to a telescope on the mountain. Eventually, Bisque and his colleagues hope to offer similar opportunities to many more people through the Internet.

"Not that far in the future we'll see whole networks of telescopes all over the world available to on-line amateurs. Any time you want to observe or image a certain part of the sky, you'll be able to do it instantly," says Bisque.

One technology that makes this virtual presence possible is the CCD camera. At its heart is a silicon chip very efficient at capturing light and converting it into a form computers with the right software can turn into an image. Will this powerful tool threaten conventional film's preeminence in astrophotography?

"Definitely," exclaims Bisque. "When you think astrophotography 10 or 20 years from now, you'll think CCD. All of its hardware and software will get more capable and cheaper. Someone with an 8-inch scope and a CCD will have thousands of objects to go after; literally a lifetime of fun."

There's one barrier that must come down if everyone is to embrace this brave new world of CCDs, and that is its aura of "black magic." Few of today's CCD users fully understand the technology's nuances, either mechanically through using the camera or dynamically through the software that processes images. Bisque contends there's still much that must be done to do bring CCDs to the masses. Only then will its full potential be tapped.

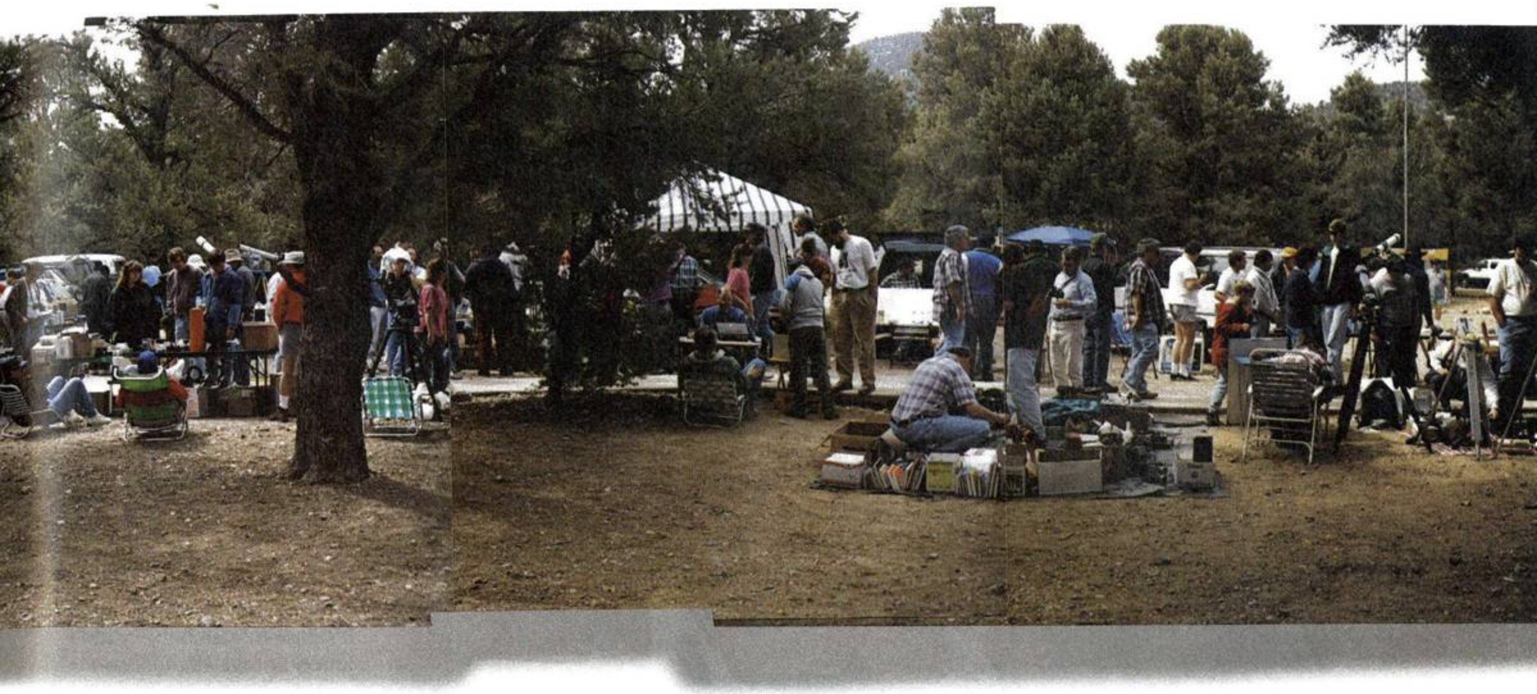
One mover in this comprehension effort says the best way to demystify a CCD camera is to build one, to immerse yourself in a world of understanding. Oh, and he says you can save money too.

Your Basic VolksCCD

Richard Berry, the former editor of ASTRONOMY is the co-author of *The CCD Cookbook Camera*, a how-to book that lets readers build a CCD camera from scratch for under $300. Since 1993 the guide has sold about 4,000 copies and helped up to 1,000 amateur astronomers make their own imagers.

In Berry's mind, there's no better way to really learn how a CCD ticks. "Building a Cookbook Camera lets you master the ropes before more capable and expensive chips appear between now and 2000," he says. "Unless you've cut your teeth on something as straight-

"The computer will be a natural part of the telescope, as natural as an eyepiece." — *Steve Bisque*



forward as a Cookbook CCD, you may be over your head even trying to follow the field."

Rolling up the sleeves and connecting components to one another allows you to better visualize the workings of a CCD camera and by extension, gauge its potential. Many builders mention they can actually visualize in their minds what a CCD camera does because they've assembled one, from the circuit board network to the cooling system that uses a pail of water and fish tank pump.

What kind of person takes on the CCD Cookbook camera?

"When I wrote the book, I expected to see people in their 20s and 30s," says Berry. "But most tend to be retirees or folks over 45 who have been in astronomy for many years. For the most part, they've seen M51 a hundred times and are looking for something new to revitalize their hobby."

In Berry's case, he had been in the hobby for 30 years, done photography, observed thousands of deep-sky objects, and built a precision 12-inch scope. He's greeted the CCD's emergence with all the zeal of a newcomer.

"I'm like a teenager again, when I built my first scope in high school," he says. "Today I'm using one of the first telescopes I made, a 6-inch reflector, to image down to magnitude 19.5 and capture things I can't even see in my 20-inch telescope!"

But for all his enthusiasm, Berry is concerned that CCD cameras will not live up to their full promise. In his opinion, the cameras are more than just a slick way to take pictures.

"People should either build a CCD camera or buy a modest commercial one, and then explore the interesting stuff CCDs can do, like astrometry (precise measurement of a star's position), photometry (measuring a star's brightness), and monitoring the planets. What will probably happen is that they will be used to get still more pictures of bright Messier objects," he laments.

Even if the cameras only end up being used for pretty pictures, what a wonderful way to capture the sky. CCDs offer astrophotographers the closest thing to instant gratification: five-minute deep-sky exposures with instant access to the results on a portable computer in the field.

Ain't Nothin' Like the Real Thing

Ask any traditional astrophotographer whether this new technology will eclipse the richness and resolution of conventional film. They'll smile quietly, look down, and kick clods of dirt while mumbling, "well . . . it's got a ways to go. . . ."

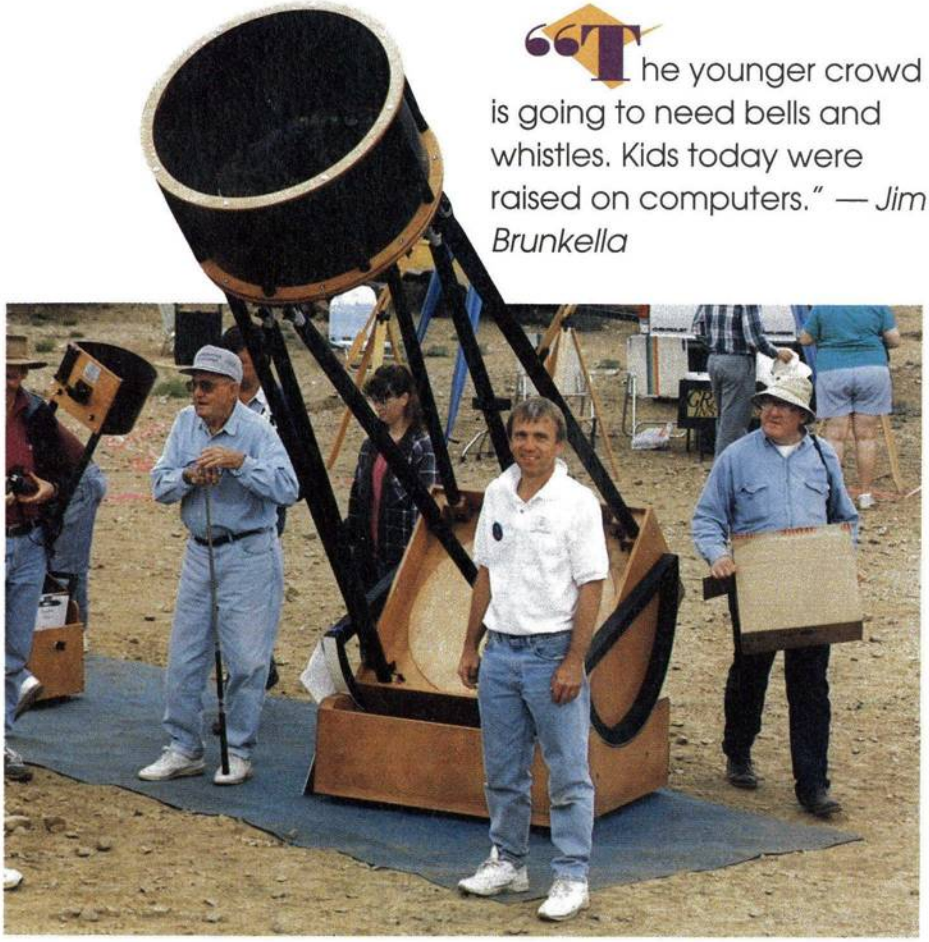
Tony Hallas is one of those traditionalists. You see his work splashed throughout most popular astronomy magazines. He knows what he wants and has bought all the elements needed for good pictures, including a medium-format camera and an expensive astrographic telescope.

In a way, CCDs have been very liberating to this photographer, but not for reasons you might think. The only CCD Hallas uses is one that's mounted in an automatic tracker. It guides the scope during exposures while — get this — he *sleeps in his car.*

"Yeah, I set the alarm to

"People should buy a modest CCD camera and explore the interesting stuff it can do, like astrometry, photometry, and monitoring the planets." — *Richard Berry*

> "The younger crowd is going to need bells and whistles. Kids today were raised on computers." — *Jim Brunkella*



wake me when the exposure ends," he admits. Until he picked up his autoguider, Tony and wife Daphne were shackled to a guiding eyepiece for exposures up to 90 minutes. According to Hallas this "was very tiring, especially if I had to work the next day."

They're useful tools now, but Hallas feels it'll be a while before CCDs ever replace film.

"They do some things better than film, like shorter exposure times and better light-gathering efficiency, but these chips are tiny," he says. "Even the largest chips are dwarfed in area by your typical 35mm frame. In astrophotography, film area translates into resolution. Maybe 10 years from now, when the big chips get cheaper, film will move aside."

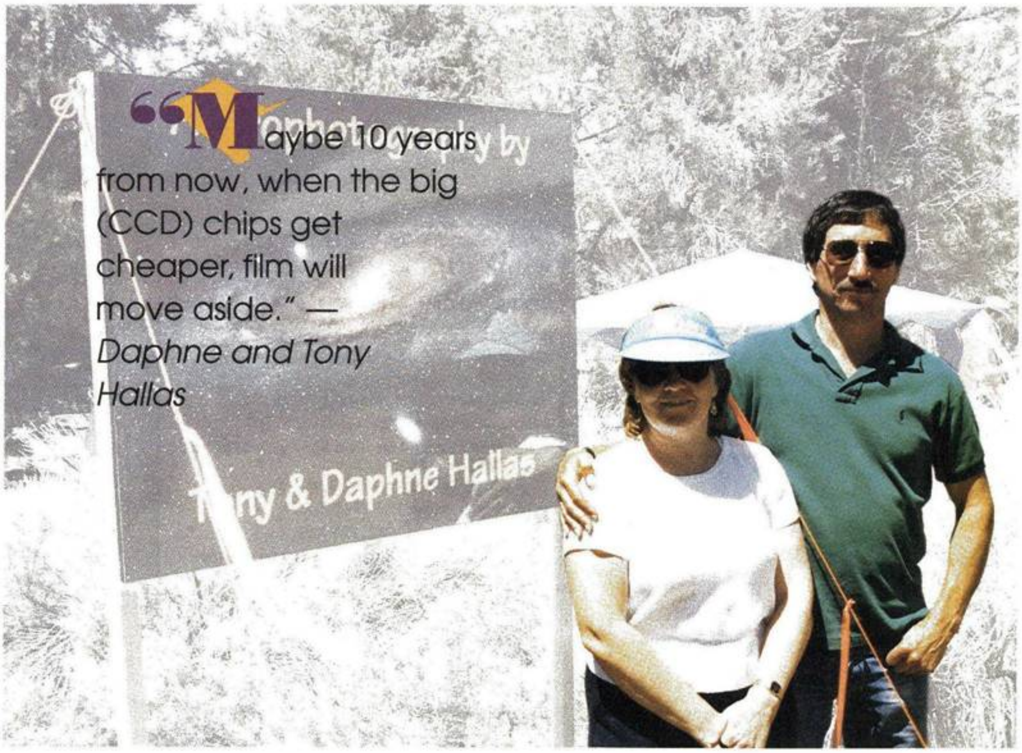
Until then, the only CCD in Hallas' life will be of the autoguider variety. "It will free up my time to do more observing," says Hallas. To this end, he and his wife are buying a 25-inch f/4 Dobsonian. "These scopes are where the other revolution lies: big, compact optics."

The ATM/Industry Connection

At places like Riverside, it's easy to watch the revolution unfold. Big Dobsonians on Poncet equatorial mounts, reflectors on Schaffer equatorial mounts, long- and short-focus optics . . . any design variation the fertile human mind can research, fabricate, and use has at one time or another showed up at ATM gatherings.

For the most part, designs are driven by function. Optical and mechanical features optimize certain types of observing or photography, and often can't be found on the commercial market. In fact, many ATMs discover their creations are so popular, they begin making optics or whole telescopes for a living.

RIVERSIDE'S MOUNTAIN VENUE adds to the star party's popularity.



“Maybe 10 years from now, when the big (CCD) chips get cheaper, film will move aside.” — *Daphne and Tony Hallas*

That's what happened to Jim Brunkella. By attending gatherings like Riverside and reading telescope-making journals, he picked up some design ideas and started making large-aperture Dobsonians for himself. Two years ago, after a friend commissioned a telescope, he decided go into the telescope-making business.

To Brunkella, Dobsonians to come will have even bigger mirrors and shorter tubes, store easily, fit in a car, and only require a modest ladder to reach the eyepiece.

He also sees Dobsonians with lap top computer controls and motors that slew. “The younger crowd is going to need bells and whistles. Kids today were raised on computers . . . their demand is what's going to drive the hobby,” he says.

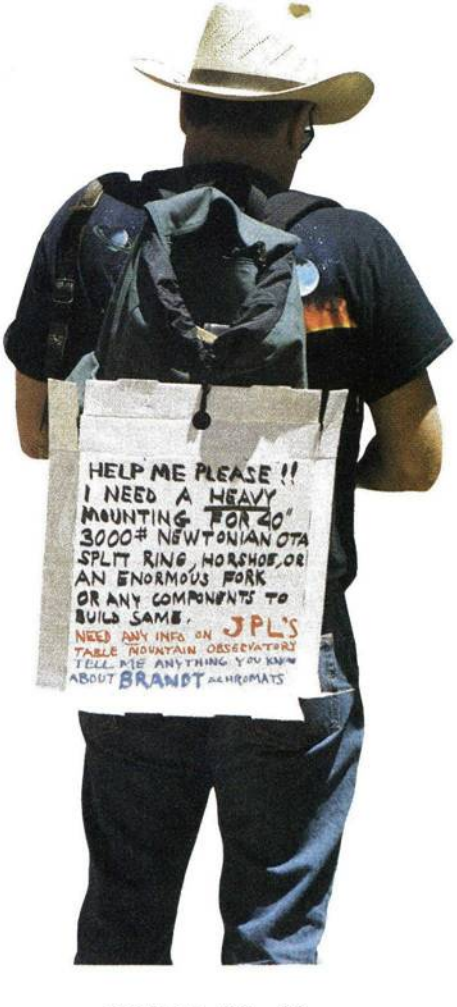
Another hobbyist-turned-professional is Peter Ceravolo. As a teen Ceravolo immersed himself in optics and telescope making to better enjoy the night sky. That led to a career in optical engineering, a life that's allowed him to design telescopes for professionals and amateurs alike. His company is a doorway through which professional-grade telescope ideas intermingle with ideas from amateur astronomers.

“ATMs play a vital role in the health of our hobby,” he says. “They drive the technology and innovation we eventually see marketed commercially. Look at ATM and Celestron founder Tom Johnson. Before he perfected the vacuum-formed corrector plates, a Schmidt-Cassegrain telescope cost thousands of dollars.”

Dovetailing into what ATMs pursue are the tools and techniques professionals use today. Ceravolo sees some pretty amazing developments coming from the “pro” side of astronomy. “We'll see computers and optics blend to correct for unsteady seeing and even permit optical interferometry,” he predicts. Interferometry uses several smaller scopes to form the equivalent of one big one, up to many feet across.

All this isn't idle chitchat. Ten years ago Riversiders mused of CCD cameras, astro-computing, and monster Dobs, but such things only existed in the realm of conversation. Yesterday's dreams have become today's reality.

If there's one thing you learn from Riverside it's this: When 1,700 fertile minds come together under starry skies in the mountains of Southern California, it's very hard to define what exactly constitutes “the future.” It's merely a facet of the present you and I haven't discovered yet. To many of these people, astronomy's future exists in the here and now. The rest of us only have to perk up and embrace it. ☐



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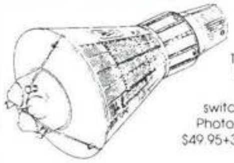

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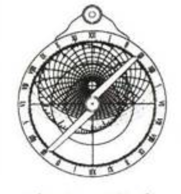

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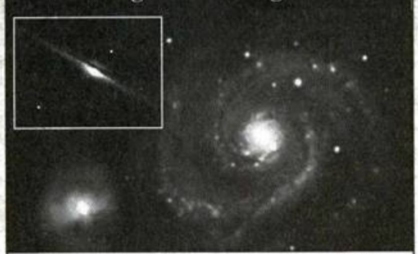

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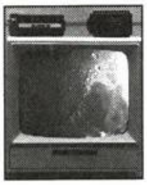

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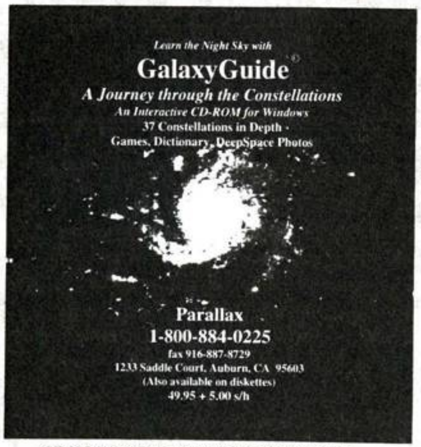

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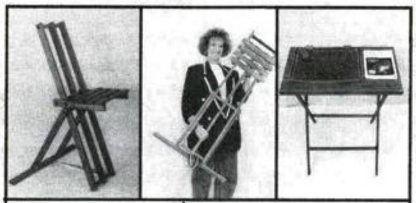

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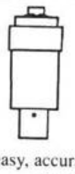

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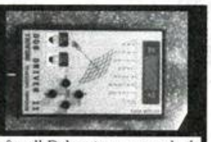

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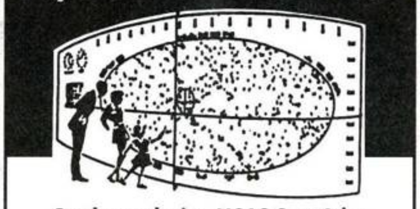

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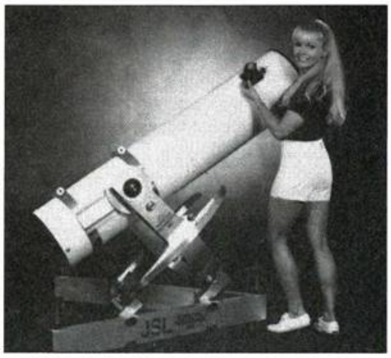

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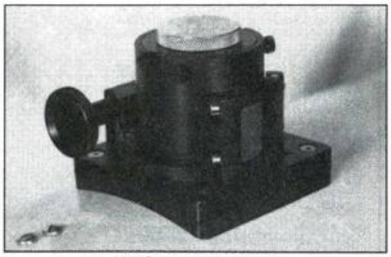

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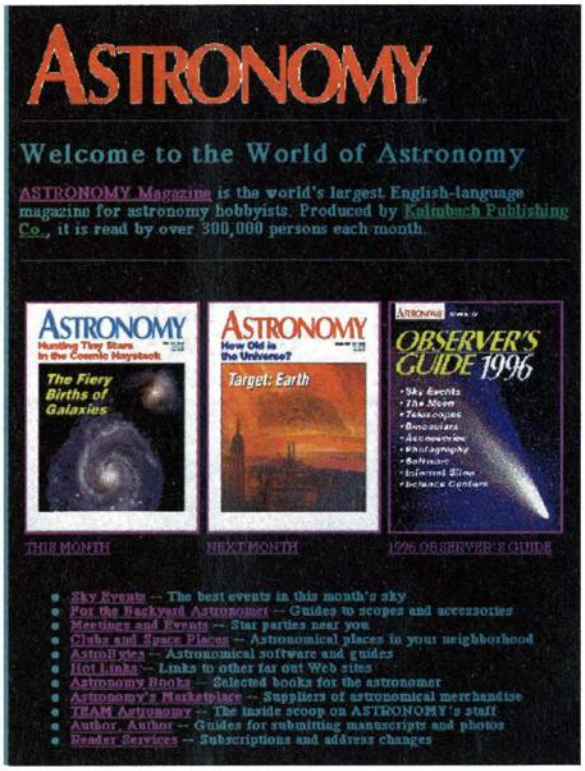

ASTRONOMY

Welcome to the World of Astronomy

ASTRONOMY Magazine is the world's largest English-language magazine for astronomy hobbyists. Produced by Kalmbach Publishing Co., it is read by over 300,000 persons each month.

THIS MONTH NEXT MONTH 1996 OBSERVER'S GUIDE

- Sky Events -- The best events in this month's sky
- For the Backyard Astronomer -- Guides to scopes and accessories
- Meetings and Events -- Star parties near you
- Clubs and Space Places -- Astronomical places in your neighborhood
- AstroBytes -- Astronomical software and guides
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To help you find the resources you need, ASTRONOMY magazine now has a set of pages on the World Wide Web. These pages contain links to astronomy clubs, museums, planetariums, observatories, and image collections. Beginning astronomers will find helpful hints for choosing a telescope, selecting eyepieces, and using binoculars to view the night sky. Parents buying a scope for a child will receive tips for making a wise purchase. Telescope shoppers and builders will find a complete list of telescope and accessory manufacturers.

Home computer owners can download popular programs that have appeared in ASTRONOMY, such as software to find the longitude of sunrise on the Moon, the best times to view Jupiter's Red Spot, and longitude of Mars' central meridian. They'll also find a guide to buying astronomical software and an address list of software developers.

Observers will appreciate the monthly planet guides and lunar phase calendars. The pages also contain a preview of the best sky events in 1996 and a listing of star parties around the country. Observers and armchair astronomers will find the books they have been looking for in the on-line book catalog. The pages also contain information on how to submit photographs, reader reports, and letters to the editor. We'll add many more resources before this issue reaches the newsstands.

To see all that these pages have to offer, viewers should use *Netscape 1.1* and a color monitor. Other Web browsers will display most of the features. ASTRONOMY's home page is located at **http://www.kalmbach.com/astro/astronomy.html**. We welcome comments on the pages and requests for other information to be added to these pages. Send them to bytes@astronomy.com.

Aperture

Willmann-Bell, Inc., P.O. Box 35025, Richmond, VA 23235, (804) 320-7016, fax (804) 272-5920. Price: $24.95. Minimum requirements: 80286-based computer and an EGA display. The developer recommends an 80386-based computer, a math coprocessor, and a VGA display.

Imagine the image of a bright star formed by a telescope. It's not a point of light as thought by beginning observers but rather a system of concentric rings. The round mirror or lens of the scope interacts with the light waves coming from the star to form a diffraction pattern of rings centered on the central disk, called the Airy disk.

Many amateurs test the quality of their optics by defocusing a star's image slightly and reading the shape of the rings (see "Test Your Scope's Optics," July 1994). Perfect optics will produce the same concentric rings on both sides of the focus. But what does it mean when the rings appear flattened on one side of focus and egg-shaped on the other?

Dick Suiter wrote *Aperture* to enable a user to produce star images on a computer to understand what star tests are saying about a scope's optics. The program can mimic the effects of spherical aberration, a turned edge, and the central obstruction caused by a secondary mirror in a reflector. It is also a useful tool for studying the image contrast produced by a set of optics.

Most users will probably use the grayscale output from this program to analyze their star tests. But the program will also plot point spread functions, optical transfer functions, and phase plots for those who want to study the optical performance in depth. Users can print any of these displays on an Epson-compatible, LaserJet, or PostScript printer.

Another program by Suiter called *Admir* ($19.95) enables telescope makers who grind their own mirrors to determine the quality of their optics. Most amateur opticians use the simple Foucault test to analyze which parts of the mirror are focusing inward or outward of the ideal position. *Admir* takes the measurements from the Foucault test and converts them into waves of light to see how the mirror deforms the light waves. *Aperture* can use the results from *Admir* to produce a star test image.

FOSTER

Software Bisque, 912 Twelfth Street, Suite A, Golden, CO 80401, (800) 843-7599, fax (303) 278-0045. Price: $69. Minimum requirements for CCD ROM multimedia sampler: IBM PC-compatible computer, Windows 3.1, and a CD-ROM drive.

FOSTER is a multimedia product aimed at CCD users who want to improve their imaging results. *FOSTER* stands for Focus, Optics, Seeing, Tracking, Experience, and Review, which provides a quick summary of the components making a good CCD image. Part of the *FOSTER* package is a book that describes focusing, pixel size versus resolution, stellar brightness and a CCD's brightness range, optical aberrations affecting an image, pixel sensitivity, flat fielding, tricolor imaging, and other topics of interest to beginning and experienced astroimagers.

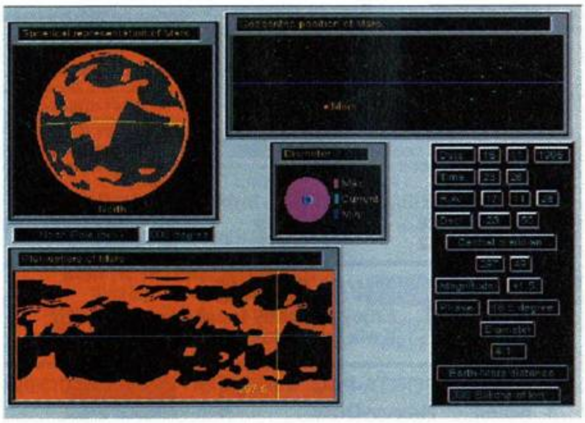
The other part of *FOSTER* is a rich offering of images, a selection of before- and after-processing images with notes, and an electronic version of the book with audio captions for the images. It also includes a demo version of *SkyPro* that will do everything the standard version of the image-processing program does except it won't save processed images, print them, or operate a CCD camera. The image selection not only provides a wealth of CCD frames for practicing image-processing techniques, but the included annotations reveal the secrets that the image-processing pros use to get the most from an image.

Central Meridian of Mars 1.1

Claude Duplessis, 104 Rang Ste-Catherine, Yamaska, QU J0G 1X0, Canada, e-mail claude_d@mksinfo.qc.ca. Shareware price: $15. Minimum requirements: IBM PC-compatible computer, Windows 3.1, and an EGA monitor.

Central Meridian of Mars provides all the information Mars observers need to study the Red Planet. Users enter the date of interest and their time zone and it provides four pictures: the orientation of the disk and the planet's poles, a rectangular map of the surface with the central longitude marked, a comparison of the present size of the planet with its smallest and largest sizes, and the location the planet in the sky. The sky map and diameter plot help observers determine the best times to view the planet

Options include a removable grid, labeling of major surface features, and translation of the instructions and menu items into French or Spanish. The program doesn't directly support printing of the maps for use at the telescope, but users can copy the window to the Windows clipboard and print it out from *Clipboard Viewer* or *Paintbrush*. □



Central Meridian of Mars

Software developers may send copies of their new and upgraded programs to AstroBytes, Astronomy Magazine, P.O. Box 1612, Waukesha, WI 53187-1612 or e-mail bytes@astronomy.com.

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Thousand Oaks Optical solar filters are recognized around the world for their quality, consistent density and even coating across the entire aperture. Thousand Oaks Optical specializes in solar filters only and is the largest solar filter manufacturer. Tens of thousands of their filters are in use around the world. The preferred choice of telescope dealers and used exclusively by NASA aboard the Space Shuttle. Other professional users include: ABC, CBS, NBC & CNN News, NOVA, Discovery, National Geographic and most major universities and observatories throughout the world.

GLASS — Type A (Blue Label)
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Type A & B are for unlimited visual use and general photographic use. Instructions, including tips on solar photography are included with all filters.

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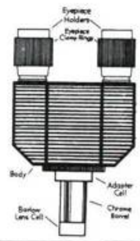

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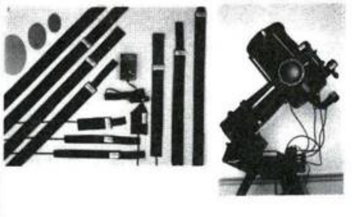

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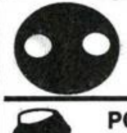

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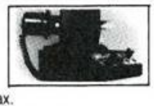

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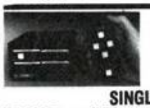

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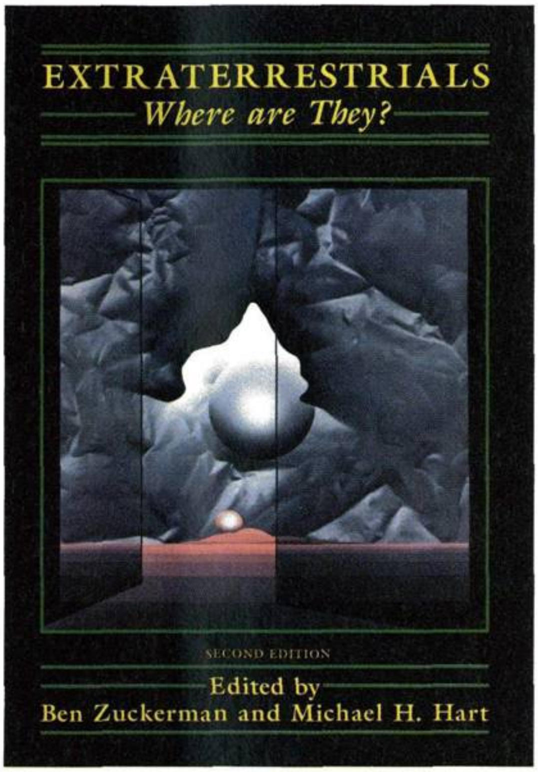
ASTRO BOOKS

Alien Nation

Extraterrestrials Where are They?

Second edition, Ben Zuckerman and Michael H. Hart, editors, (Cambridge University Press, 1995), ISBN 0-521-44335-0 (hardcover), $39.95, ISBN 0-521-44803-4 (paperback), $19.95, 228 pages.

In chapter 17 of this new book, UCLA biologist Jared Diamond states that exobiology — the study of non-Earthly life — is "the sole scientific field whose subject matter has not yet been shown to exist." This volume, an updated version of a 1982 book of the same title, includes a variety of essays relating to the preponderance of intelligent life, and most adhere closely to Diamond's cynical tone. The title itself comes from the great physicist Enrico Fermi, who when asked if he believed in extraterrestrials, replied "Where are they?"



The editors, astronomers Ben Zuckerman of UCLA and Michael Hart of Anne Arundel Community College in Maryland, belong to perhaps a minority of astronomers who believe that the negative answer to Fermi's question gives strong evidence that humanity is indeed alone, at least in the Milky Way Galaxy. Nine of the book's 22 chapters are devoted to the feasibility of interstellar travel, most concluding that a civilization with sufficiently advanced technology will spread through the Galaxy, eventually colonizing the Milky Way in a few million years. Our failure to see any evidence of these galactic colonists (or their astroengineering projects) provides compelling evidence that other civilizations do not exist.

The most valuable additions to the new volume are two chapters written by biologists, UCLA's Diamond and Ernst Mayr of Harvard. Biologists as a group tend to be more skeptical toward the existence of extraterrestrial intelligence than their physical scientist counterparts. Diamond puts forth compelling arguments that the evolution of intelligent beings capable of interstellar communication is exceedingly improbable. Mayr takes a similar tack, but unfortunately the editors did not include his essay "The Probability of Extraterrestrial Intelligent Life" from his 1988 book *Toward a New Philosophy of Biology*, which makes a far more convincing case against the existence of other civilizations.

While this book is rather technical in spots, most of the text is accessible to ASTRONOMY readers. The 1982 version contained 17 chapters, 15 of which are essentially repeated here. The new version contains five totally new chapters, and two that update chapters in the original version. Those who own the 1982 version will likely be disappointed with the lack of new material. But this new volume is the perfect antidote for those who haven't read the original book and who have received an overdose of ET-optimism in the popular press. — *Robert Naeye*

The Great Comet Crash: Comet Shoemaker-Levy 9 and its Impact on Jupiter

John R. Spencer and Jacqueline Mitton, editors, (Cambridge University Press, 1995), ISBN 0-521-48274-7, 160 pages, hardcover, $24.95.

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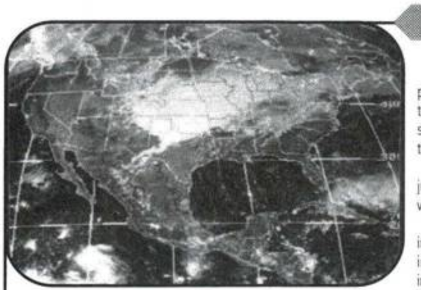

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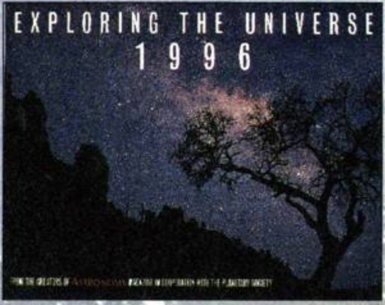
Exploring the Universe 1996 Calendar



From the editors of ASTRONOMY Magazine. Amateur astronomers will enjoy twelve months of spectacular celestial sights and events in this 1996 astronomy calendar. Color photos and artwork capture stellar images like the Hubble Space Telescope in orbit, a vast ocean of stars in the Milky Way, and the eerie red glow of the Moon in eclipse. An informative essay accompanying each photo explains the significance of the event. Each month also includes helpful information on viewing meteor showers, eclipses, the planets, phases of the Moon, and more. 14 x 11; 13 color photos.

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audience. Much has since been written about the event in the popular and scientific press. Here, Cambridge University Press attempts to summarize in one concise yet comprehensive book for a broad, non-scientific audience what scientists have learned from the event.

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This is a tall order, but overall the book succeeds in its mission. For starters, it is heavy in photographs, diagrams, and illustrations, and light on text. It contains 10 brief chapters, each of which is written by an expert in a field relating to the comet crash. As would be expected of a book with so many authors, the chapters vary considerably in content and writing style. Most of the chapters, however, are lively and well-written. The editors, John R. Spencer, a Lowell Observatory astronomer, and Jacqueline Mitton, a public relations officer for the Royal Astronomical Society, make sure each chapter reports what a layman wants to know without bogging the reader down in extraneous technical details. All of the scientific terms and acronyms are clearly defined in a glossary.

In their foreword, Carolyn and Eugene Shoemaker provide a broad overview of the impact, and in chapter 2 they recount the story of their discovery of the comet. In chapter 3 Brian Marsden of the Center for Astrophysics writes about the comet's pre-discovery trajectory. Other chapters cover the planet Jupiter, pre-impact computer simulations of the event, the establish-

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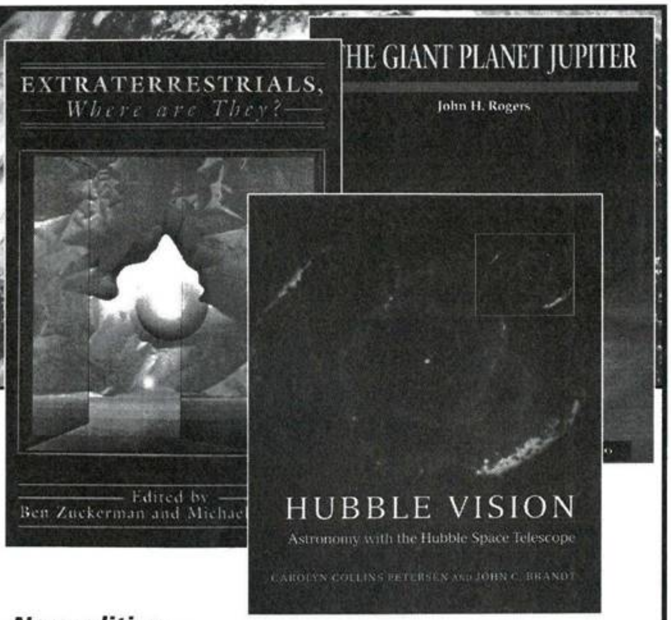

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ment of a worldwide Internet bulletin board, the nature of the comet itself (the original comet was such a loose pile of rubble that a person could have pulled it apart with his or her bare hands), and post-impact analysis. The longest chapter, by Spencer, covers the observations of the impacts by many different astronomers over the entire range of wavelengths. A short concluding section to the chapter, written by British amateur astronomer John H. Rogers, covers amateur observations. Spencer keeps this chapter as reader-friendly as possible by devoting most of the pages to photographs, diagrams, and drawings.

Clark Chapman of the Planetary Science Institute concludes the book by discussing the likelihood and consequences of a similar object crashing into Earth (see "Target Earth," October 1995). The observations of the impacts and the subsequent dark spots in Jupiter's upper atmosphere had a profound effect on all who observed them. "Hundreds of thousands of people could see with their own eyes the havoc wrought by the impact of just one piece of a modest-sized comet," writes Chapman.

The sight of Earth-sized dark splotches on Jupiter spurred the U.S. Congress into action. The legislators asked NASA to come up with plans to deal with the cosmic impact threat. The event served as a wake-up call, but Chapman warns that we're still a long way from understanding the full scope of the menace. He concludes, "With the future of civilization hanging in the balance, however small the odds, it behooves us to learn more about the impact hazard."

Scientists continue to sift through the mountains of information they collected during impact week, so the final word has yet to be spoken concerning the impact of Comet Shoemaker-Levy 9. But this book provides a fascinating and easily digestible summary of the state of knowledge as of early 1995.
— *Robert Naeye*

(Review the first chapter and table of contents of Extraterrestrials, Where are They? *and* The Great Comet Crash *are on the Internet at: http://dab.psi.net/chapterone/astronomy)*

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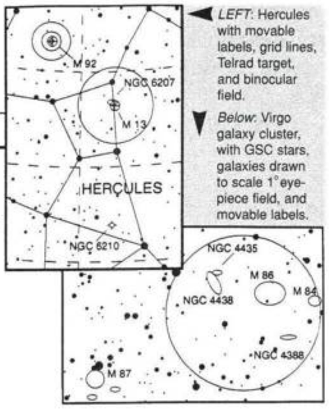

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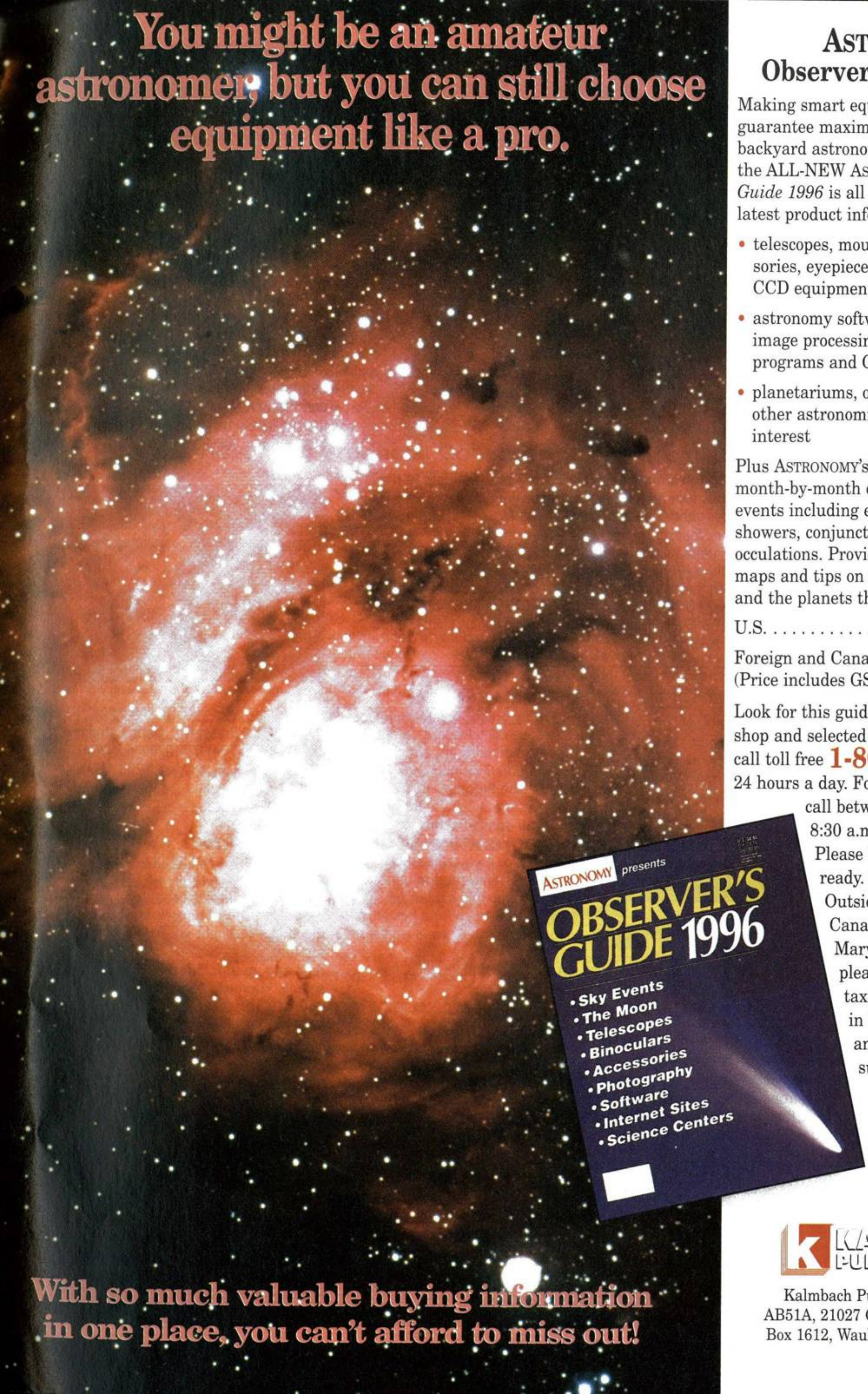
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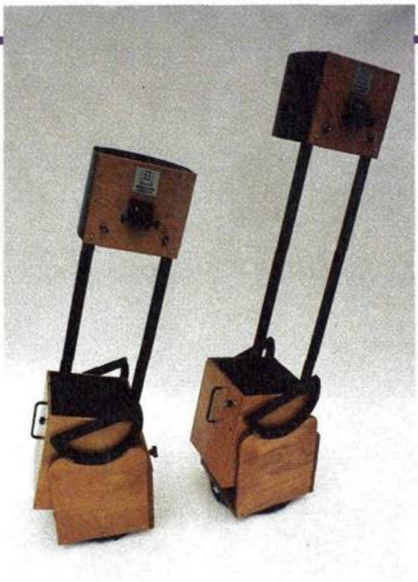
NEW PRODUCTS



Compact Dobsonian Telescopes

Starsplitter Telescopes introduces a line of compact 8-inch f/6 and 10-inch f/6 Dobsonian telescopes. Both use Pyrex glass in their optics, incorporate a JMI Crayford-style focuser, and feature a primary mirror cell that provides nine-point support. The 10-inch's secondary mirror has a major axis of 1.83 inches; the 6-inch, 1.53 inches. Teflon pads built into each telescope's rocker box rest on a baseboard to provide a smooth motion in azimuth. Cast-aluminum altitude bearings attached to the mirror box also ride on Teflon pads.

A fully assembled 10-inch aimed toward the zenith has an eyepiece height of five feet; eyepiece height for the 6-inch is four feet. Both scopes break into three components for easy transport and storage without need for tools. Two 1½-inch aluminum trusses disconnect from a secondary/focuser board, which fits into the primary box. The 10-inch's total weight is 40 pounds, while the 6-inch weighs 30 pounds. Each scope uses a Kydex light shield held rigid by stiffeners that attach to the secondary/focuser board. *A Telrad finder ($40) and a 2-inch focuser ($100) are optional.*

Starsplitter Telescopes, 3228 Rikkard Drive, Thousand Oaks, CA 91362, (805) 493-2489. 10-inch f/6 Starsplitter Dobsonian: $799; 6-inch f/6: $699. Crating and shipping charges are extra; California residents add 7.25% sales tax.

Upgraded Refractor

Celestron has revamped its Firstscope 80 telescope into a premium altazimuth refractor that accepts 1¼-inch eyepieces. The Premium 80 Telescope uses a 3.1-inch (80mm) f/11.4 air-spaced achromat objective lens with multiple coatings for high contrast. The mount has slow-motion controls with flexible cables for remote adjustment and has an adjustable wooden tripod. The telescope comes with a 6x30 finder, a 45° erect image diagonal, and a 26mm Plössl eyepiece.

Celestron International, 2835 Columbia Street, Torrance, CA 90503, (310) 328-9560, fax, (310) 212-5835. Premium 80 Telescope, Model #21053: $1,198.

Astronaut Autographs

Space memorabilia enthusiasts can now collect genuine astronaut signatures on color 8x10 prints. Destiny International has contracted with a number of Space Shuttle, Apollo, and Gemini astronauts to personally autograph pictures of themselves taken during their respective missions. Prices range from $79 to $149, depending on the astronaut's fame and the mission pictured. Select from a separate list of astronauts that includes six different personalized greetings. Each signed print comes with a certificate of authenticity and a 30-day, money-back guarantee.

Destiny International, 1181 South Rogers Circle #28, Boca Raton, FL 33487, (407) 241-8601, fax (407) 241-8603, (800) 370-STAR (for orders). Free catalog on request.

New Products presents announcements issued by manufacturers. Product information is supplied by the manufacturers or distributors. All prices are suggested retail. Suppliers should send announcements and color photographs of their products to the attention of John Shibley, P.O. Box 1612, Waukesha, WI 53187, or newprod@astronomy.com.

Satellite Magazine

Satellite Times, a bimonthly magazine, covers the commercial and military Earth satellite scene. In its pages you'll get tips on equipment and techniques that allow you to pick up satellite radio signals, including those from weather satellites and the space shuttle. The magazine also covers trends in satellite services and satellite technology. Departments provide launch schedules along with position and radio frequency information for geostationary satellites. Elsewhere are tables that list what types of programming are carried by active communication satellites, by transponder and frequency. Other columns devote themselves to amateur ham radio satellites and the latest news from NASA.

Satellite Times
Listening in on the Shuttle
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Satellite Times, P.O. Box 98, 300 S. Highway 64 West, Brasstown, North Carolina 28902-0098, (704) 837-9200, fax (704) 837-2216. $19.95 per year, $26 (U.S.) elsewhere.

LED Flashlight

The Starlite red-light flashlight has two LEDs powered by one 9V alkaline battery. A thumbwheel on/off switch also works as a rheostat to dim or brighten the LEDs. The light runs on one battery for about 12 hours at maximum brightness and up to 625 hours on its dimmest setting. Starlite is 4½ inches long and comes with a battery, a 7" wrist strap, and a 22" neck strap.

Rigel Systems, 26850 Basswood Ave., Rancho Palos Verdes, CA 90275, (310) 375-4149 (voice or fax). Starlite Astronomer's Flashlight: $24.95, plus $4.95 shipping.

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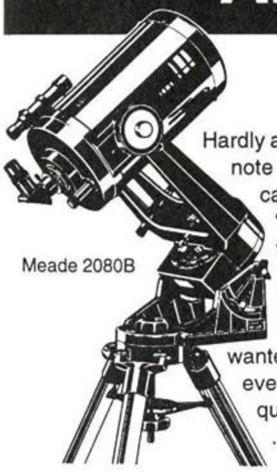
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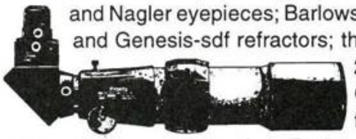
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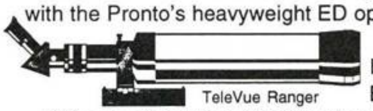
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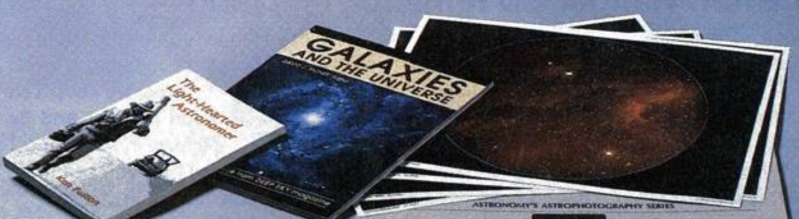
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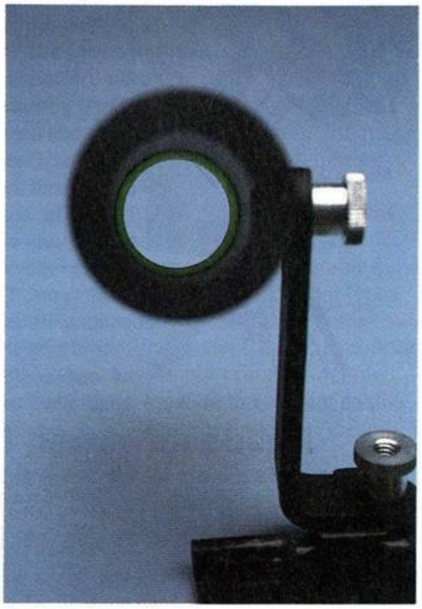

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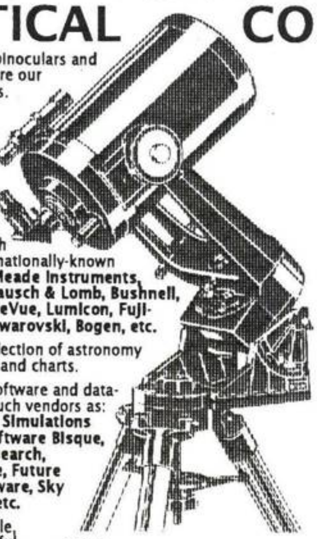

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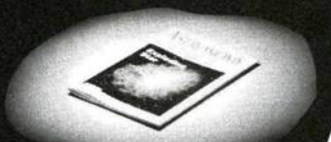

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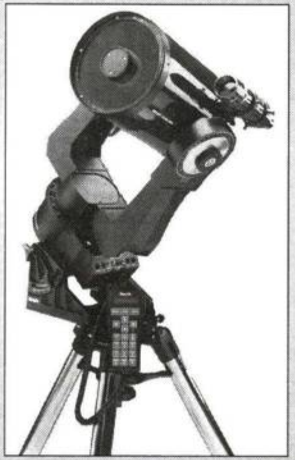

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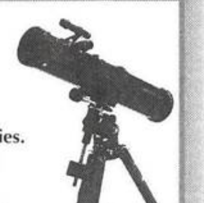

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Fourth Annual Convention of the Antique Telescope Society, Philadelphia, Pennsylvania. Hosted by Swarthmore College. Sponsored by The Antique Telescope Society. Contact Walter H. Breyer, 30 Green Valley Road, Wallingford, PA 19086.

October 27-29
Blackwater Falls Astronomy Weekend, Blackwater Falls State Park, Davis, West Virginia. Sponsored by the Kanawha Valley Astronomy Society. Contact Ron Cockeram, 5216 Bailey Road, Cross Lanes, WV 25313, (304) 776-5017 or (800) 225-5982.

November 11
Ventura County Astronomical Society Swapmeet, Moorpark College Observatory, Moorpark, California. Contact Don Holland, (805) 526-4032 or the Starline (805) 529-7813.

November 16-18
4th Annual Star Party, Kissimmee State Park, Lake Wales, Florida. Sponsored by the Lake Kissimmee State Park. Contact George Aycrigg, 14248 Camp Mack Road, Lake Wales. FL 33853.

December 16
5th Annual Star-Be-Cue, near Heathcote, Victoria, Australia. Contact Perry Vlahos, 9A Hall Street, Cheltenham, Melbourne, Victoria 3192, Australia, 03-9583-5930.

January 27-February 2, 1996
Photonics West '96 Symposium, San Jose Convention Center, San Jose, California. Sponsored by the International Society for Optical Engineering. Contact SPIE, P.O. Box 10, Bellingham, WA 98227-0010, (360) 676-3290, spie@spie.org.

February 15-18, 1996
The Orange Blossom Special, Hickory Hill Observing Complex, near Brooksville, Florida. Sponsored by the St. Petersburg Astronomy Club, Inc. Contact Dennis Farr, 8811 West Broard Street, Tampa, FL 33615, (813) 884-9111. □

Please submit announcements four months before the date of the event to Meetings and Events, P.O. Box 1612, Waukesha, WI 53187-1612, or use astro@astronomy.com. Include a self-addressed, legal-sized envelope when writing to organizations listed here.

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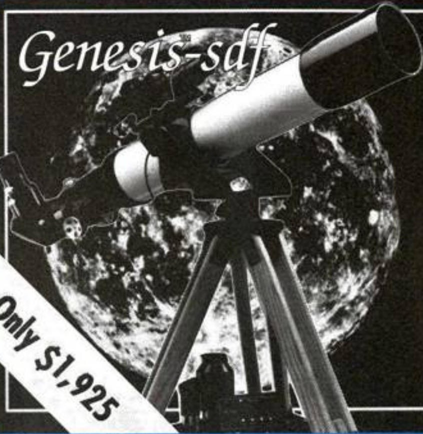

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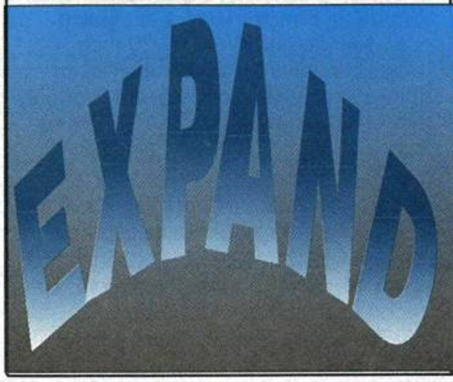

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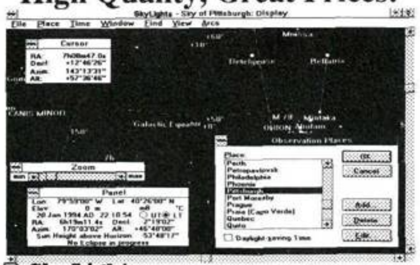

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RESOURCES & PHOTOFACTS

Curtains at the Edge of the Universe (page 48)

The Big Bang, by Joseph Silk, (W. H. Freeman and Co., 1989). A good introduction to cosmology and the early universe. It describes subatomic particles such as gravitons, quarks, and neutrinos and the curtain of radiation formed by the young universe.

Was Einstein Wrong? (page 54)

Was Einstein Right? Putting General Relativity to the Test, by Clifford Will, (Basic Books, 1986). A staunch defender of relativity describes various experimental tests of Einstein's theory. Includes a chapter on the binary pulsar.

"The Apsidal Motion of the Eccentric Eclipsing Binary DI Herculis — An Apparent Discrepancy with General Relativity," by Edward F. Guinan and Frank P. Maloney, *Astronomical Journal*, August 1985, pp. 1519-1528.

"Eclipsing Binary Stars as Tests of Gravity Theories: The Apsidal Motion of AS Camelopardalis," by Frank P. Maloney, Edward F. Guinan, and Patricia T. Boyd, *Astronomical Journal*, November 1989, pp. 1800-1812.

Deep-Sky Zoo (page 72)

Burnham's Celestial Handbook, by Robert Burnham, Jr. (Dover, 1978). A massive, three-volume set of information, photos, and diagrams relating to deep-sky objects in all 88 constellations. The data must be used with care, but generally the stories in this work stand up well.

The Universe from Your Backyard, by David J. Eicher (Cambridge University Press, 1988). A constellation-by-constellation tour of deep-sky objects and stars adapted from the pages of ASTRONOMY. Includes much information on other "beastly" denizens of the night sky.

Stars and Galaxies, edited by David J. Eicher (Kalmbach Books, 1992). A compilation of ASTRONOMY articles with photos, maps, and descriptive text about observing hundreds of star clusters, nebulae, and galaxies, including many belonging to the celestial zoo.

Celestial Photography (page 80)

Astrophotography for the Amateur, by Michael Covington (Cambridge University Press, 1985). A step-by-step tour through the equipment, techniques, films, and approaches used for various kinds of night sky photography. Includes information on large formats as well as 35mm techniques.

A Manual of Advanced Celestial Photography, by Brad D. Wallis and Robert W. Provin (Cambridge University Press, 1988). Includes much detailed information of use to those taking astrophotos with large-format cameras.

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pp. 72-73: Emery Hildebrand, 11-inch SCT at f/2.5, Ektachrome 400 film, 45-minute exposure; **p. 74, top:** Barry Sobel, 8-inch SCT at f/6, hypersensitized SR 1600 film, 30-minute exposure; **bottom:** Bernard Abrams, 10-inch f/5 reflector, Tri-X film, 5-minute exposure; **p. 75, top:** Pedro Ré, 14-inch SCT at f/7, Hi-SIS22 CCD camera; **bottom:** Jack Newton, 25-inch f/5 reflector, SBIG ST-6 CCD camera; **p. 76, top:** Martin C. Germano, 14.5-inch f/5 reflector, hypersensitized Tech Pan film, 65-minute exposure; **bottom:** Pedro Ré, 14-inch SCT at f/7, Hi-SIS22 CCD camera; **p. 77, top:** Jack Newton, SBIG ST-6 CCD camera; **bottom:** Jack Marling, 24-inch f/15 Cassegrain, 30-minute exposure; **pp. 80-81:** Luke Dodd, 55mm lens at f/4, hypersensitized Fuji 400 film, Pentax 6 x 7 cm camera, composite of two 20-minute exposures; **p. 81:** Alfredo Zanazzo, 16-inch f/4 SCT, hypersensitized Tech Pan film, 4 x 5 camera; **pp. 82-83:** Tony and Daphne Hallas, 7-inch f/7 refractor, hypersensitized Fuji Super HG 400 film, 120-format.; **p. 83, top:** Luke Dodd, 55mm lens at f/4, hypersensitized Fuji 400 film, Pentax 6 x 7 camera, composite of two 25-minute exposures; **bottom:** Luke Dodd, 4.8-inch f/8.5 refractor, Fuji 400 film, Pentax 6 x 7 camera, composite of two 60-minute exposures; **p. 84:** Peter Ledlie, 105mm lens at f/3, hypersensitized Fujicolor 100 film, Pentax 6 x 7 camera, composite of two 30-minute exposures; **p. 85:** Roland Christen, 5-inch f/8 refractor, Kodak Ektar 25 film, Pentax 6 x 7 camera, taken July 11, 1991, from San José del Cabo, Baja California, Mexico; **p. 121, top:** Per-Jonny Bremseth, 8-inch f/10 SCT at 80x; **bottom left:** Per-Jonny Bremseth, 8-inch f/10 SCT at 166x; **bottom right:** Per-Jonny Bremseth, 8-inch f/10 SCT at 166x; **p. 122, top:** Ronald W. Kohl, 20-inch Cassegrain, Star I CCD camera, taken June 19, 1995; **bottom:** Ronald W. Kohl, 20-inch Cassegrain, Star I CCD camera, taken June 20, 1995; **pp. 122-123:** George Greaney, 5-inch refractor at f/6, hypersensitized Fuji Super HG 400 film, composite of two 60-minute exposures; **p. 123:** Giovanni Dal Lago, 11-inch SCT at f/5, Starlight Xpress CCD camera, 10-second exposure; **p. 124:** Arlo F. Niederer, 4-inch refractor at f/4, Ektar 1000 film, 15-minute exposure. ☐

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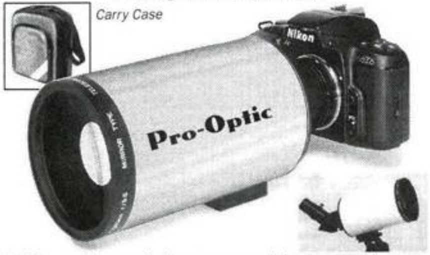

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With the addition of the 'SS500 Kit you can convert it to a 20X 90mm spotting scope. The SS500 kit includes a 45° 1.25" Erect Image Diagonal and a 25mm 1.25" Plossl

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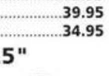

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COMING IN THE DECEMBER 1995 ISSUE OF ASTRONOMY

Michael Stecker

EXPLORE ORION'S GREAT NEBULA A medium-size scope reveals stunning detail in winter's showpiece deep-sky object, but the right filters will help you see new shapes and boundaries.

THE MARS THAT NEVER WAS Forty years ago, space artist Chesley Bonestell fired an entire generation's imagination with visions of Martian canals, wetlands, and possible primitive life.

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CELESTRON'S NEW REFRACTOR This redesigned 4-inch apochromatic refractor features superb optics on a sturdy German equatorial mount.

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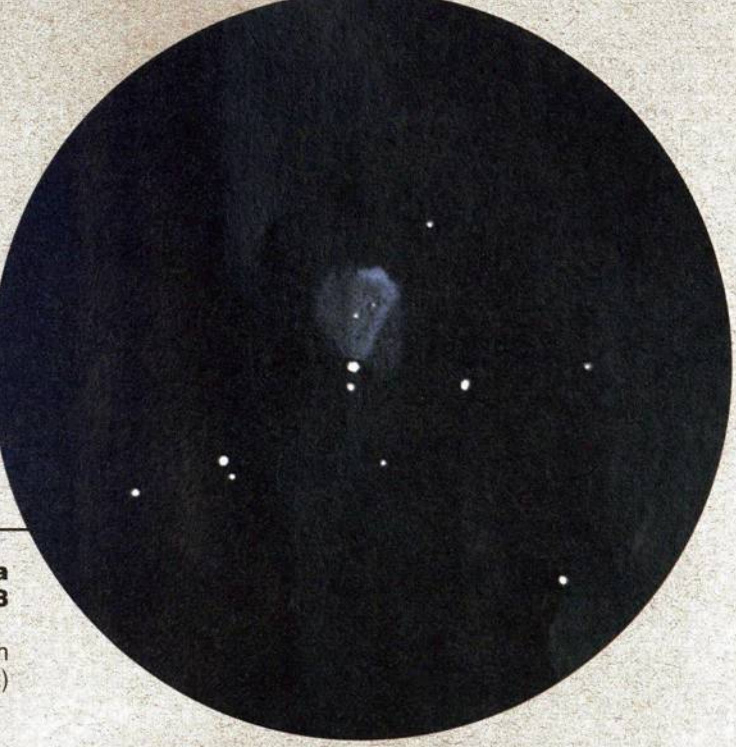
Deep-Sky the Old-Fashioned Way

"My main interest is comets," says Per-Jonny Bremseth, an enthusiastic backyard astronomer from Ranheim, Norway. "But I have observed many variable stars, have photographed deep-sky objects, and made drawings of them. I especially love to make drawings of the objects because it gives a more natural impression of what I see in the eyepiece."

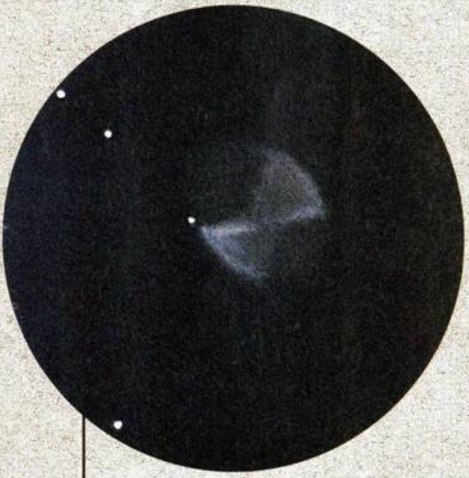
Bremseth's sketches depict galaxies and nebulae as seen with an 8-inch f/10 SCT. "I think the Orion Nebula (M42) is the finest object in the sky," he says. What excites Bremseth is the view of M42: a bright green glow of gas with four bright diamonds (the Trapezium cluster) and a sharply defined, right-angle edge in the southwestern part of the nebula. "Delicate wings of light wind outward from the center and fill the field of view," he says. "Streamers of gas to the southwest are visible, too." Its ultimate satisfaction comes from realizing that this glow is a giant star factory spanning dozens of light-years.

A nebula that marks the end of a star's life, the Dumbbell Nebula (M27) in Vulpecula, also offered a rewarding target for Bremseth's sketchbook. "It's a grand planetary nebula," he says. "At first I thought the object resembled an hourglass, but later I saw more of a Z-shape. The color was a striking green." Bremseth notes that the southwestern part of the nebula is the brightest, and he observes sharp edges on the northeastern and southwestern sides. The outer "ears" were very diffuse and faint.



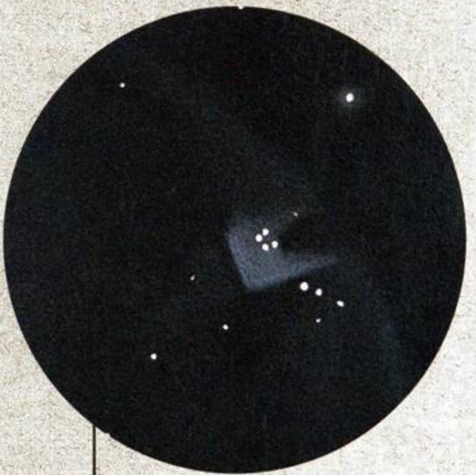
Planetary nebula NGC 7008

by Per-Jonny Bremseth (8-inch f/10 SCT at 166x)



The Dumbbell Nebula

by Per-Jonny Bremseth (8-inch f/10 SCT at 166x)



Core of the Orion Nebula

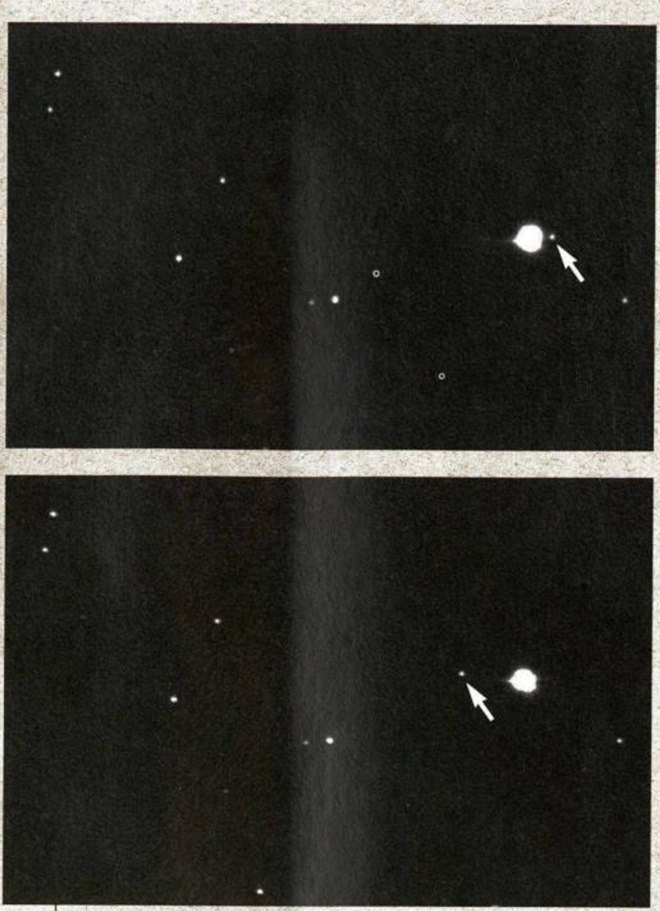
by Per-Jonny Bremseth (8-inch f/10 SCT at 80x)

Nearby, NGC 7008 in Cygnus is another planetary nebula with pretty structure visible in small scopes. "It looks like a narrow sail stretching northward with a 9th-magnitude star in the southern end of the boat," says Bremseth. "At first glance I could see only the narrow sail, but later I detected a fainter part of the nebula to the west. Two very faint stars were embedded in the nebula's soft light."

Alpha Monocerotid Outburst? Meteor observer Robert Lunsford reports that prospects for the Alpha Monocerotid meteor shower are especially good this year. The minor shower peaks on the night of November 21/22, 1995, and may produce a very short outburst, "lasting 5 to 10 minutes and producing a Zenithal Hourly Rate of more than 1,000." (The Zenithal Hourly Rate is the number of meteors an observer would see under ideal conditions if the radiant, the point from which the meteors appear to originate, were straight overhead.)

"Normally the shower produces just five meteors per hour," says Lunsford. Short outbursts have been observed in 1925, 1935, and 1985. There may be a 10-year periodicity associated with this shower, which originated from Comet Van Gent-Peltier-Daimaca, last seen in 1944. The outburst in 1985 lasted about six minutes. Observers should monitor the sky throughout the evening and early morning hours, and the peak comes at 10 p.m. EST on the 21st. Readers should report observations to Astronomy. □

Astronomy wants to hear about your observations of the sky. Send reports, sketches, and photographs to David J. Eicher, Reader Reports Editor, Astronomy, P.O. Box 1612, Waukesha, WI 53187. Please label each photo with name, address, and social security number. You may send written reports via the Internet to: rreports@astronomy.com

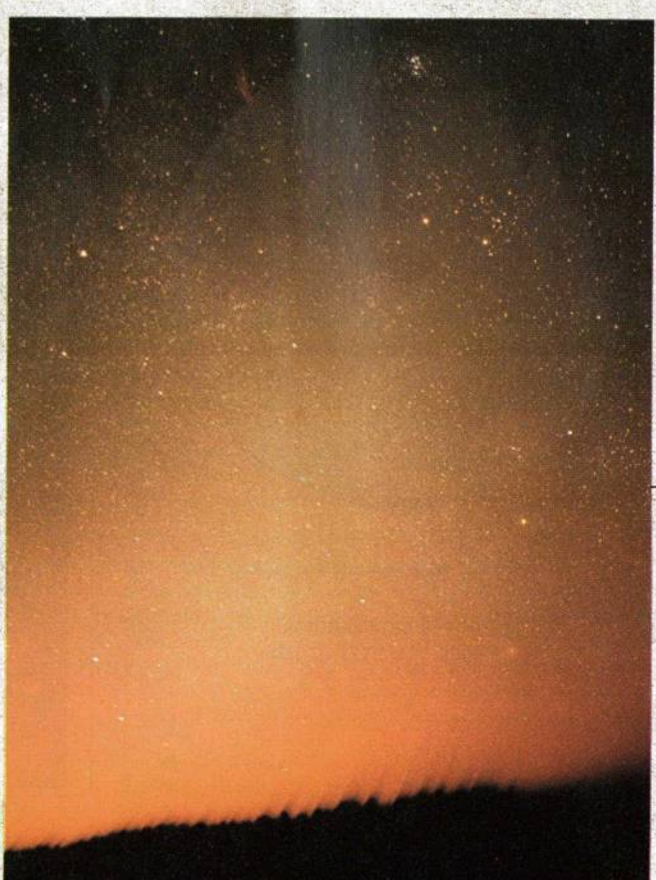


Pluto (arrow) Passes Bright Star SAO 140853

by Ronald W. Kohl
(20-inch Cassegrain, Star I CCD camera, taken June 19 and 20, 1995)

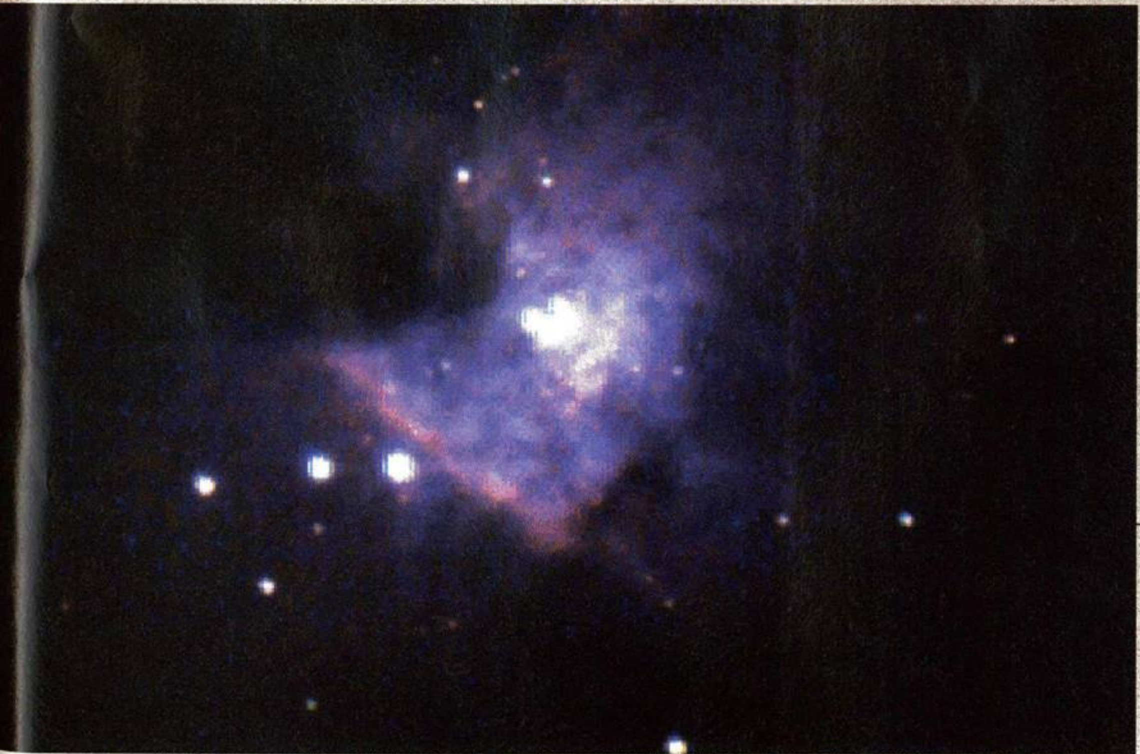
The Cone Nebula in Monoceros

by George Greaney
(5-inch refractor at f/6, hypersensitized Fuji Super HG 400 film, composite of two 60-minute exposures)



Dawn's Light, the Pleiades, and the California Nebula

by Ronald E. Royer
(24mm lens at f/2.8, Fuji Super HG 400, 20-minute exposure on August 10, 1992)

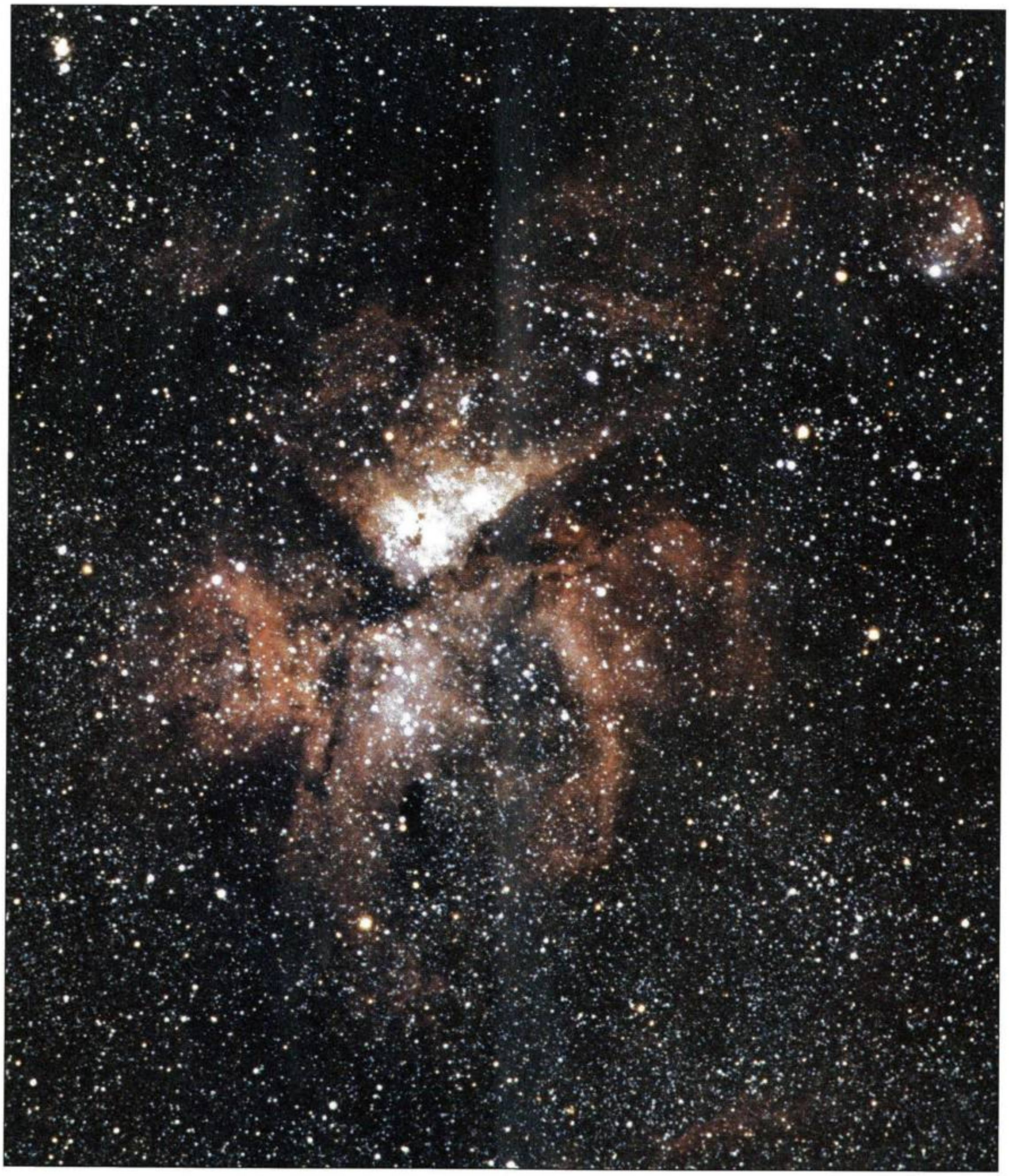


The Trapezium Region of M42

by Giovanni Dal Lago (11-inch SCT at f/5, Starlight Xpress CCD camera, 10-second exposure)

Ultimate Exposure

Wins $100 as Astronomy's Best Astrophoto



The Eta Carinae Nebula

by Arlo F. Niederer
(4-inch refractor at f/4, Ektar 1000 film, 15-minute exposure)

"I consider the region of the Eta Carinae Nebula the most beautiful in the sky, and am struck by the considerable number of details visible in the image," says Niederer. The Louisiana amateur mounted a 35mm camera at the prime focus of his refractor and shot the nebula on a trip to Australia in February 1994. "I photographed the object from the Leon Mow dark sky site of the Astronomical Society of Victoria," says Niederer. "It's an area near Heathcote, Victoria.

"Thanks for your magazine and its superb photographs, which provide a standard to strive toward."

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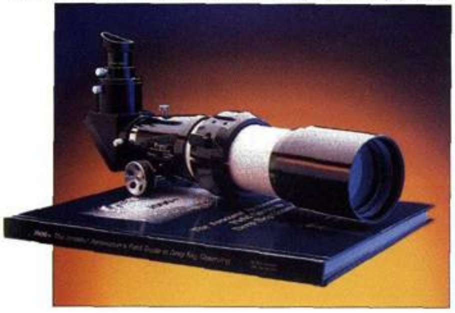

No picture or description prepared me for the beauty of the design or the excellence of the workmanship. J.T. - RI

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I am greatly satisfied with the quality of craftsmanship that was put into this fine instrument. M.H. - PA

Fantastic! Sharp views of planets, moon and star fields...excellent high power results!! J.C. NJ

It's the only scope I recommend to friends. B.H. - KS

Superb optics! Sharpest images of any scope I've ever owned. Pinpoint star images. R.M. MD

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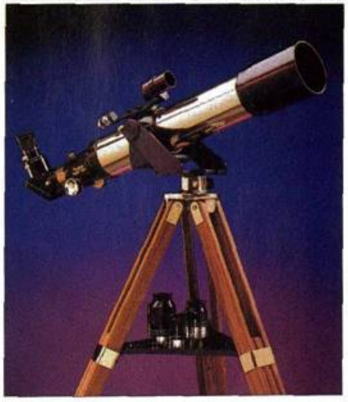

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The **Ultima® 9¼** introduces a new and unique aperture to the astronomical community. The mount is a rugged sand cast aluminum design. The wedge and tripod are both newly designed for added rigidity and stability. The electronics are the same as used in the highly successful Ultima 8 — and run with a 9 volt battery for totally cordless operation. The DC Servo Quartz drive system combined with a super precision gear set gives unprecedented drive accuracy.

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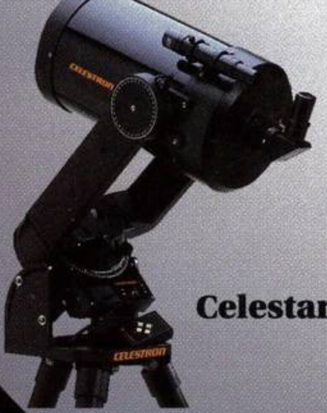

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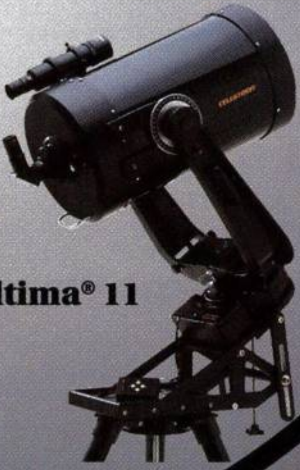

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